THE INDUSTRIAL MUSEUM

CHARLES R. RICHARDS

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By

CHARLES R. RICHARDS

DIRECTOR OF
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PREFACE

In 1919 the National Society of Vocational Education obtained from the General Education Board a grant which enabled the society to make a survey of art in industry. An extensive report dealing in detail with the situation in respect to the application of art to the various industries was brought out in the year 1922.

After the publication of this report it was suggested that the next step to be taken involved a study of museums of industrial art abroad. This study the writer undertook in behalf of the American Association of Museums in the year 1923-24, visiting museums in the following countries: England, Sweden, Denmark, Germany, Austria, Hungary, Czecho-Slovakia, Switzerland, France, Belgium and Holland. In general, two types of museums were studied—industrial museums and museums of industrial art. The results of the survey will be published in the form of two complementary volumes, the first of which is now offered to the public.

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CHAPTER I

PURPOSE AND SCOPE

In the Far East, particularly in India, the processes of production that underlie the daily life are revealed to every passerby. In the open booths of the bazaar are to be seen the brass and copper metal workers shaping pots and pans, the tailor working on his garments, the jeweler and silversmith at his tiny forge. At the end of the street is the weaver with his loom, and women working at the spinning wheel or reeling thread. The dye pots, where the finished cloth is dipped, are in a house close by and long strips of freshly colored cloth are borne down the street at frequent intervals on the way to the owner's house where they will be hung up for drying. At the edge of the village near a convenient clay bed the potter throws the common water jars or other earthenware vessels on his wheel. Nothing is hidden from common observation that enters into the material life of the community.

With us in the West all this is different. The processes of production that underlie the civilization of today are hidden behind factory walls where only the specialized factory worker enters. Little is known about these operations by the growing boy and girl. To attempt to present these things through books is unsatisfactory and tame. The processes must be revealed to the eye and set forth in the simplest and clearest possible fashion if the foundations of our present-day life are not only to

be understood, but to become an element in the culture of today.

The industrial museum in its highest development endeavors to accomplish this purpose by displays of materials that clearly and succinctly illustrate industrial processes in ways that may be readily understood by both young and old.

If it be granted that this educational aim is the paramount purpose of an industrial museum and its theme the industrial basis of our present-day life, it is important to define the scope appropriate to the collections of such a museum, to set up standards for its displays, and to specify its secondary activities.

Regarding the scope of the collections, we may well begin with the methods by which food, clothing, and shelter have been obtained. Food getting implies first of all primitive methods of hunting and fishing, the care of flocks and the tilling of the ground. The preparation of food leads shortly to the simple beginnings of pottery and the fabrication of metal pots and pans; later glass appears. Shelter involves the evolution of primitive dwellings from the cave and the brush lean-to to the use of tents, then of houses constructed of clay, brick, wood, thatch, and stone. Heating, lighting and water supply develop in this connection.

To furnish clothing we have first of all the dressing of skins, leather and furs, leading to the beginnings of the textile arts founded upon the spinning and weaving of plant and animal fibers.

The need for communication appears early and hieroglyphic forms are followed by writing. Transportation by animal power on land and by crude forms of rafts and boats on the water were developed in prehistoric times. Very early in this effort to meet growing needs appears the working of metals—copper and bronze, and finally iron.

Primitive industry had developed into the various

practical forms just noted by the beginning of the Christian era. Tilling of the soil employed the same methods as are in use today. Thread was spun not only from the wool of sheep and goats but also from cotton, flax and silk. Dyeing and printing of fabrics were practiced. Tanning of leather was universal. The potter's wheel was used for throwing earthenware vessels, and lead glazes had been applied to render vessels water-tight. Iron was dug from the earth and smelted, and crude steel was manufactured.

For the next sixteen centuries these primitive craft processes continued to be employed with but little variation. By the time of the High Renaissance a few other important inventions and improvements had been added. The wool and the flax spinning wheels had been introduced into Europe, bringing with them greater speed and facility in the production of yarn. The manufacture of paper had been developed and printing with movable types invented. A method of producing cast iron from ore in large quantities had been discovered, and iron casting brought into general use.

These simple industrial methods supplied the needs of the world until the end of the eighteenth century when the industrial revolution was brought into being by a number of notable inventions in the form of labor saving machines driven by mechanical power. In a brief time the steam engine was developed into a practical prime mover; quantity production and the division of labor became the ruling policies of industrial manufacture. For the new machines metals were in increased demand and improvements in the processes of mining and smelting were thus forced. Coke was successfully used as fuel in the blast furnace. The puddling furnace was invented. Rolling mills were introduced and the process of making crucible steel evolved.

The modern era thus ushered in has witnessed a remarkable extension of scientific knowledge through the

application of which industrial progress has been greatly accelerated. During this period extraordinary developments have taken place in the efficiency of prime movers, in the manufacture of steel, in specialized automatic machines, in land and sea transportation, in chemical industries, in manifold applications of electricity, and, most recently of all, in the art of aeronautics.

Thus the world of industry has changed from a craftsman's world to a factory world. The extent of production is no longer gauged by muscular strength, but by the almost unlimited power of physical and chemical forces. Man, instead of being himself a motor, has become more and more the controller and director of energy.

On the other hand, while production has been enormously stimulated in respect to both quantity and speed, the basic operations involved in a large proportion of the industrial processes of today are much the same as in the simple primitive methods. The human hand has been replaced by cams, gears, levers, belts, and pulleys, and human energy has been supplanted by mechanical power, but at the heart of the machine still appears the operation that in one form or another has been practiced through the centuries.

It would seem clear that it is to the exposition of the basic industries in their simple forms, together with the elementary processes of agriculture, mining, and early methods of transportation and communication that the industrial museum should first address itself. Such displays should constitute its first purpose. Upon these as a basis should be built the amazing story of the inventions, devices, machines, and methods that the nineteenth and twentieth centuries have brought to bear upon our daily life.

There is little question that a comprehension of modern highly developed processes and apparatus can best be gained by displays that first set forth the primitive

method, or at least the simplest embodiment of an idea, followed by the important progressive steps in their historic order. In addition to such a presentation through full-sized specimens or models, every resource of descriptive labels, diagrams, plans, colored representations, and statistics should be utilized to bring out the fundamental ideas involved with the maximum of clearness.

Inasmuch as the central idea can be readily confused by multiplicity of material, group exhibits should be reduced to the simplest terms. Only significant steps should be selected for illustration. Apparatus dealing with ideas of only secondary importance should be excluded and the library relied upon to complete the story.

Apparatus should be so arranged as to reveal construction and operation in the clearest manner. This is often best accomplished by sectioning certain portions. Where this is impracticable, sectional drawings or diagrams should be used. Wherever motion is essential to comprehension of the operation, apparatus should be so arranged that it can be actuated, either by hand or mechanical power.

The industrial museum should make further provisions to forward its educational program. First among these are arrangements for the explanation and illustration of the exhibits by trained custodians. In addition, a lecture theater equipped with projection apparatus for still and motion pictures should be provided, and frequent public lectures given at stated times, dealing not only with various aspects of industrial development, but with industrial topics of special contemporary interest, with new inventions and scientific discoveries. Provision should also be made for temporary exhibitions of material relating to industrial or technical subjects brought specially into prominence by events of the day.

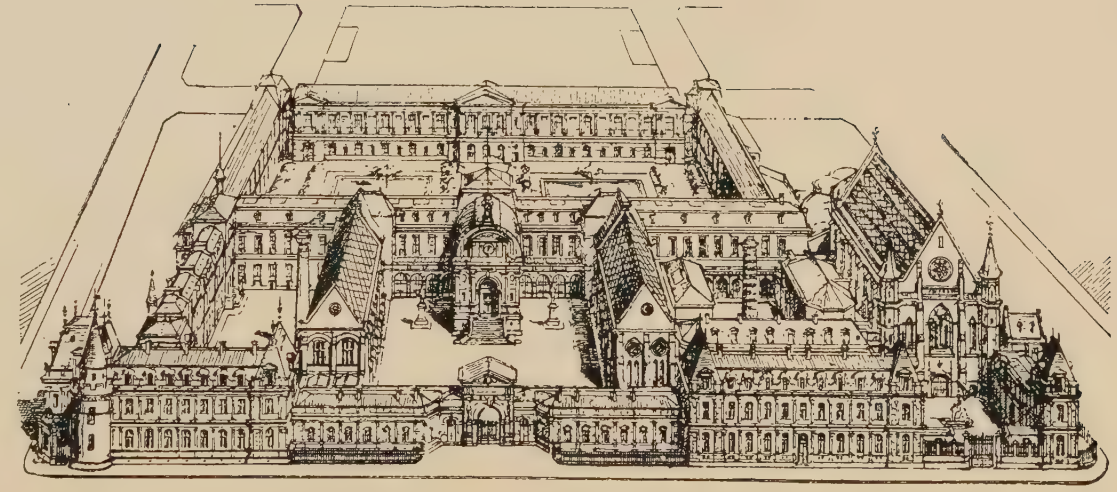
The principles and policies just outlined would seem to be the inevitable outcome of the purpose and problem

of the industrial museum. From these points of view it will be well to examine the organization and practice of existing industrial museums.

While logically it might well have originated in the United States, the industrial museum, as a matter of fact, first found embodiment in Europe. Four comprehensive industrial museums exist: the Deutsches Museum in Munich, the Technisches Museum in Vienna, the Science Museum in London, and the Conservatoire des Arts et Métiers in Paris. There are also the beginnings of an industrial museum in the Palais Schwarzenburg at Prague called the Bohemian Technical Museum.

Besides these comprehensive museums, there exist a number of special museums devoted to particular subjects or divisions. In Germany there are three railway or traffic museums; there is also one in Budapest. There is a museum of oceanography in Berlin, and a museum of similar type in Monaco. There are marine museums in Paris, Amsterdam, and Rotterdam, and a very important museum of agriculture in Budapest.

The museums just enumerated were established with various aims in view; they therefore naturally differ as to the degree in which their collections and methods of display fulfill the educational purpose set forth above.



Conservatoire des Arts et Métiers.

CHAPTER II

CONSERVATOIRE DES ARTS ET MÉTIERS, PARIS

First of the museums of industry to be established was the Conservatoire des Arts et Métiers in Paris, in the year 1799. The conception was first outlined by Descartes who proposed a museum containing scientifie instruments and the tools of the several mechanical trades. His project provided that a skilled artisan or mechanic be attached to each trade group to answer questions regarding processes and the use of tools.

The plan, however, was not realized until a century later when, during the period of the Directory, the following decree was passed by the Convention in 1794.

Article 1—There shall be formed at Paris, under the name of the Conservatoire des Arts et Métiers, and under the instruction of the Commission of Agriculture and the Arts, a public depository of machines, models, tools, drawings, descriptions, and books of all the arts and trades; originals of instruments and machines invented and perfected shall be deposited at the Conservatoire.

Article 2—The construction and use of tools and machines employed in the arts and trades shall be explained there.

The decree was not at once put into effect, but later on, in 1798, under pressure of public sentiment, the Council of Five Hundred adopted a resolution establishing the Conservatoire in the buildings of the old priory of Saint-Martin-des-Champs. The following year the Conservatoire took possession of these buildings and transferred there the collections of scientific apparatus and models of machines previously made by Vaucanson and by the Academy of Sciences during the old régime.

The ancient church of the priory, of which the choir was built in the eleventh century, is still used as an exhibition hall, and the refectory, dating from the twelfth century, now houses the library. The priory buildings, added to at various times, now represent a series of rather narrow exhibition halls comprising about 86,000 square feet of floor area. The lighting of many of the rooms is extremely poor. This is true to such an extent that the contents of wall cases are often invisible.

The scope of the museum collections may be indicated by the following divisions: physics, electrical industries; geometry, weights and measures; mechanics and machines, transportation; chemical industries; mining and metallurgy; graphic arts; textile arts; arts of construction; agriculture; industrial accident prevention, and industrial hygiene.

The collections represented at first the whole scope of the Conservatoire. In 1819 a new step was taken through the creation of public courses on science applied to the arts and industries. Testing laboratories were added to the Conservatoire in 1901. They comprehend the following sections:

1. Physics dealing with tests of thermometers, indicators, optical and photographic apparatus, and weights and measures.

2. Materials testing as applied to metals, wood, cordage, textiles, rubber, etc.

3. Materials testing as applied to limestone, cement, sand, plaster, ceramic products, glass, slate, etc.

4. Machine testing as applied to generators, hydraulic motors, pumps, internal combustion engines, and machine appliances.

5. This section is limited to the study of vegetable substances and to chemical tests of material dealt with in the other sections.

A museum of safety and of industrial hygiene was

Conservatoire des Arts et Métiers. Transportation Hall.

organized in 1904. In this department there are a considerable number of metal working and wood working tools and examples of textile apparatus provided with safety appliances which are shown in operation.

The Conservatoire is administered by a Board of Managers numbering twenty-six, which exercises considerable autonomy in administering the affairs of the institution. The Board is constituted of senators, deputies, educational officers of the government, municipal counselors, industrialists, representatives of engineering and learned societies, and professors from scientific, industrial and technical schools. The director is appointed by and is responsible to the Under-Secretary of State for Technical Education, who is an official of the Ministry of Public Instruction and Fine Arts. The internal organization is as follows: conservateur, assistant conservateur, chief guardian, brigadier, guardians, laborers. The Conservatoire is mainly supported by government subventions, but fees are also obtained from the testing laboratories that form part of the institution.

Among the noteworthy elements in the collection are ornamental turning lathes, some of them the gift of the Czar Peter the Great to the Academy of Science; a collection of calculating machines and examples of the abacus; an extensive collection of early spinning and weaving machinery, especially the Jacquard loom; physical apparatus from the laboratory of Lavoisier; the work of Daguerre and other early photographic inventors; objects illustrating the history of time measurement embracing an extensive collection of clocks.

Only repairs to models are made in the museum workshops. All models are constructed either by industrialists, in which case they are often presented to the museum, or by specialists outside the museum, in which case they are paid for.

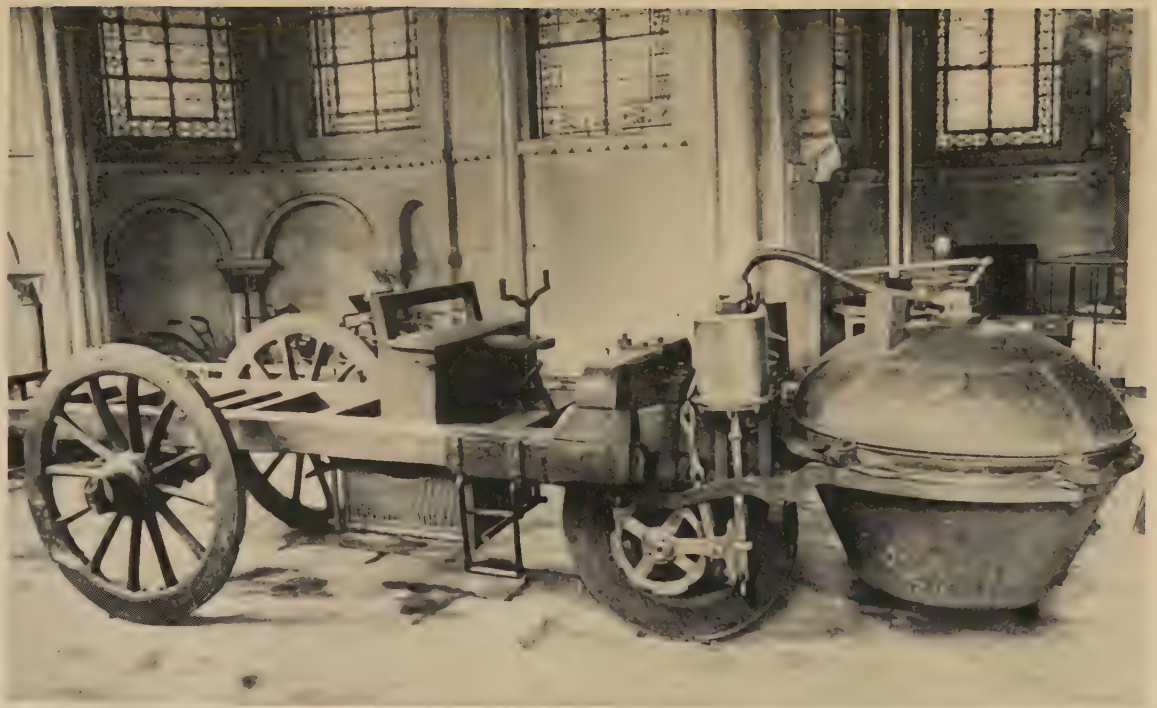
The library of the museum contains some 53,000 vol-

umes relating to science, art, agriculture and industry. It is open each week day from 10 a. m. to 3 p. m., and from 7 p. m. to 10 p. m.

Between the years 1905 and 1910, six official catalogues of the collections were published. These are still available and although not brought up to date, contain a fairly comprehensive inventory of the models existing in the collection. The first volume deals with mechanics and machines, locomotion and transportation; the second with physics, heat, acoustics, optics, magnetism and electricity, telegraphy and telephony and meteorology; the third with descriptive geometry, geodesy, cosmography, astronomy, nautical science, chronometry, measuring instruments and weights and measures; the fourth with chemical industries, dyeing and printing of textiles, ceramics and glass; the fifth with graphic arts, photography, spinning and weaving, mining, metallurgy and the working of metals; the sixth with the arts of construction and civil engineering, industrial art, domestic economy, hygiene, agriculture, and rural engineering.

From a museum standpoint the value of the Conservatoire rests entirely upon its very extensive collection of models of tools, machines, apparatus, and industrial buildings. These models are in most cases beautifully made, but no educational principle seems to have guided their selection. The significant invention or forward step is lost in the mass of material. Again, no attempt has been made to bring out the nature of basic industries by the illustration of primitive or early methods followed by progressive steps arranged in series. Scarcely any explanatory matter in the form of representations, drawings, diagrams, or labels has been used to make clear the processes or principles involved. A few of the models can be operated electrically, but the proportion is very small.

In short, the educational possibilities of the collections



Conservatoire des Arts et Métiers. Motor vehicle of Cugnot, 1770.

have not been developed. The Conservatoire is today merely a great storehouse of material, valuable to the technical student and the engineer, but undeveloped in the educational sense.

CHAPTER III

THE SCIENCE MUSEUM—LONDON

REALIZATION of the need of diffusing more widely knowledge respecting vital national industries led to the creation in 1853 of a Museum of Science as an integral part of the Science and Art Department of the Privy Council. The collections, largely based on a nucleus left from the Crystal Palace Exposition of 1851, were arranged for public inspection for the first time in 1857 in temporary buildings at South Kensington. At first they consisted only of foods and animal products; to these were subsequently added educational apparatus gathered by the Society of Art and presented by that body to the government in 1857. Collections comprising structures and building materials were formed later.

Concurrently with the organization of the Science Museum a patent museum was opened in 1857 in an iron building at South Kensington. This museum languished and eventually the contents were handed over by the Patents Law Amendments Act of 1883 to the Science and Art Department.

A naval and marine engineering collection was commenced in 1864 when the Royal School of Naval Architecture was founded at South Kensington. The collection, consisting very largely of objects brought together by the Admiralty at Somerset House, was transferred in 1873 to the Naval Museum at Greenwich; in the interval, however, it had been largely extended, not only by loans and gifts from private shipbuilding and engineering firms, but also by purchase,—a condition that has since continued with the result that this division has grown to very large proportions.

Science Museum. Façade of new wing.

An International Loan Collection of Scientific Apparatus was held in London in 1876. The residue left at its close formed the nucleus of a collection illustrating the application of physics, chemistry, astronomy, and other pure sciences which has since been augmented to a notable extent.

In 1899 the Board of Education, constituted as a Department of State, took over, among other activities, the work of the Science and Art Department. In 1908 the Science Museum began its independent existence. In this year the science collections were removed from the Victoria and Albert Museum and separately housed in galleries to the west of Exhibition Road. These galleries are not as a whole well suited for display purposes, inasmuch as they are lacking in rooms of sufficient size and height to accommodate large specimens.

From the early years of its existence, Royal Commissions, Treasury, Departmental, and Select Committees had examined the collections of the Science Museum and had reported thereon. The consensus of the recommendations made by these bodies was that the museum should be developed in definite directions, that the temporary buildings should be replaced by permanent ones, that funds should be found for purchases, and that an adequate staff should be employed. Little, however, resulted until a deputation of eminent men of science urged upon the president of the Board of Education the need for action. A Departmental Committee, created in 1910, presented in 1912 a report of such convincing and authoritative character that the Government authorized the erection of a new building on the existing site.

The shell of this structure, finished before the outbreak of the World War, was then handed over to other departments. In 1923 the work of completion was begun, and at the end of 1924 the ground floor was finished and objects were installed.

The completion of this entire building will add floor

space approximating 135,000 square feet to the 45,000 square feet formerly available. The new building will, for the first time, provide the museum with large exhibition halls which will accommodate suitably its many examples of large machines and engines.

The Science Museum is now administered by the Board of Education. There is an advisory committee of twelve members who report annually to the president of the Board on the conduct of the museum and its needs.

The museum is headed by a director; its technical and directing staff is as follows:

1 director at a salary of £1,200.
3 keepers at salaries ranging from £750 to £900
2 deputy keepers at salaries ranging from £600 to £750.
2 assistant keepers at salaries ranging from £400 to £600.
4 assistants at salaries ranging from £200 to £250.
4 assistants at salaries ranging from £150 to £180.
1 guide lecturer at £240.
8 technical assistants at salaries ranging from £150 to £250.

For administrative purposes the museum is divided into four divisions:

I. Industrial Machinery and Manufactures.
II. Mechanical Engineering, Land Transport and Construction.
III. Water Transport, Marine Engineering and Aeronautics.
IV. Science Collections.

In detail the scope of the museum is as follows:

Stationary engines and boilers
Land transport: roads; railways

Science Museum. View in central hall of new building.

Lifting appliances
Power transmission
Pumps
Fire protection
Structures and building construction
Water supply; sewage; sanitation
Textile machinery; sewing machines
Agricultural implements and farm machinery
Mining, ore dressing and metallurgy
Paper making; printing; writing; copying
Electrical engineering
Telegraphy, telephony, wireless
Lighting appliances
Machine tools
Marine engines
Ship models; naval architecture
Harbor and docks; lighthouses
Aeronautics; aero engines
Horology
Astronomy
Geology; geography; geophysics; oceanography
Mineralogy; crystallography
Optical instruments
Photography; kinematography
Mathematics
Meteorology
Thermal instruments
Properties of matter; physical phenomena
Acoustical instruments
Geodesy; surveying; cartography
Chemistry
Biology

The Science Museum is extremely rich in original material and models associated directly with great inventors and pioneers, such as Watt, Arkwright, Stephenson, Maudslay, Bessemer, and with men of science, among

whom may be mentioned Babbage, Herschel and Kelvin. Models and drawings of early engines of Newcomen and Watt, a locomotive of 1813, Stephenson's Rocket, and other locomotives of 1829, Arkwright's first spinning frame, a replica of Hargreaves' spinning jenny, Maudslay's first screw cutting lathe, and other mile-stones of the industrial revolution are numbered among its technical treasures.

The museum is particularly comprehensive in the divisions of textiles, land and air transportation, steam engines and early machine tools. The section devoted to water transportation is also very complete and contains models of merchant and war vessels from the fifteenth century to the sectioned models of great steamships of the present time.

Of late years much attention has been paid to the elucidation of the exhibits from the educational standpoint. A large number of the technical models have been arranged to operate mechanically, and diagrams and other explanatory matter have been effectively introduced. Much care has been taken with the labels attached to the exhibits. These labels present not only the historic facts regarding the exhibits, but describe their construction and operation.

The historical material in the museum is mainly the property of the institution, while the objects illustrating modern developments are generally secured through the courtesy of manufacturers and private persons, and are almost always on loan. As a result the basic collection is in the main permanent while the modern material is subject to continued withdrawal and weeding out to make room for more recent objects.

Up to the present time, the museum has not conducted lectures and has had no special arrangements for guiding parties through the collections. A guide lecturer will, however, be employed after the completion of the new installations. Lecture tours will be given twice daily

Science Museum. Locomotive hall, new building.

except Sunday so as to compass the entire scope of the museum in about two weeks.

In the same group of buildings is a science library, the only library of its kind in England, containing books and periodicals relating to pure and applied science, transactions of learned societies, journals, and a complete collection of British patent specifications.

The support of the museum is derived entirely from Government appropriations under the Board of Education. The appropriations for the fiscal year 1924-25 were as follows:

Salaries and wages	£40,538
Packing, mounting, and repairs and setting up objects for exhibition	2,500
Traveling and incidental expenses	1,414
Telegrams and telephone	2,500
Purchase grant	2,500
Total	£47,201

The cost of accessions to the collections and additions to the Science library is met from a so-called grant-in-aid or purchase grant. Unexpended balances of this grant are not returned to the Treasury; accumulations are thus available to meet abnormal expenditures. The average sum now spent is £1,400 a year. The expenditures of late years on additions to the Science library have been from £800 to £1,000 a year.

The museum publishes an annual report and has either in print or in process of publication the following descriptive and illustrated catalogues which, by reason of the clarity and comprehensiveness of their historical notes, form an extremely valuable compendium of mechanical inventions and industrial progress:

Mining and ore-dressing
Metallurgy (in the press)
Textile machinery

Machine tools
Aeronautics; do. supplement
Meteorology
Stationary engines and boilers
Land transport

1. Roads and road vehicles (in the press)
2. Mechanical road vehicles (in the press)
3. Locomotives and rolling stock

Water transport

1. Sailing ships
2. Steamships of war (in the press)
3. Marine engines and boilers (in the press)

Biology (in the press)
Mathematics

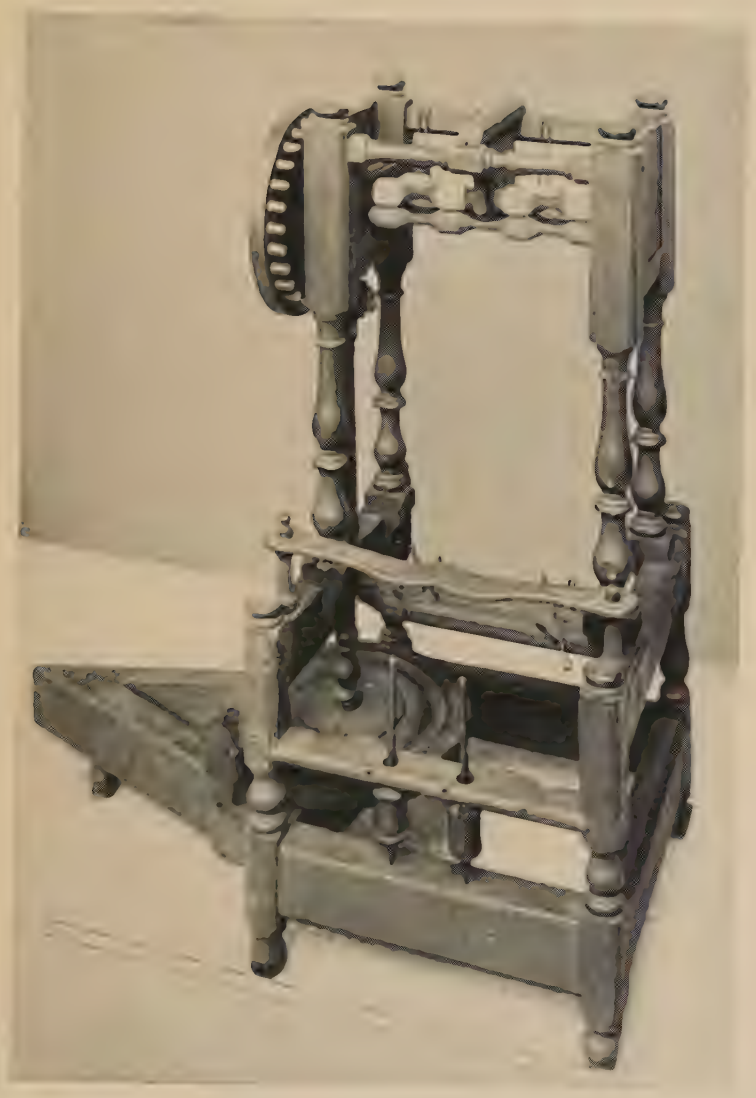
1. Calculating instruments (in the press)
2. Geodesy and surveying (in the press)

Electrical communication

1. Wireless telegraphy (in the press)

The Science Museum contains extensive collections with many original examples of great interest in the history of mechanical progress dating from the beginnings of the industrial revolution, particularly in the field of the steam engine and the railway, machine tools, and textile machinery. Some steps have been taken towards depicting the more elementary phases of industrial methods, but as yet the arrangement of material in progressive series to illustrate industrial evolution is not a conspicuous feature of the museum. The policies of the museum, however, are steadily tending to emphasize historic development, and the displays reflect more and more clearly the educational ideal.

The arrangement in the older buildings is sometimes rather miscellaneous and crowded. This condition will



Science Museum. Arkwright's first spinning frame.

be greatly relieved when the entire extent of the new building is available and the displays in these admirably planned, well lighted spaces allow at least the major portions of the collections to be seen to full advantage.

CHAPTER IV

THE DEUTSCHES MUSEUM—MUNICH [1]

In 1903 Dr. Oskar von Miller presented a plan for a museum of master works of natural science and technology to a group of government and city representatives, scholars and technologists in the city of Munich. The purpose of the museum as then outlined was to illustrate the development of natural science and technology and to present a vivid history of the influence of invention and mechanical progress upon social life. With the hearty cooperation of leading industrialists and men of science and with assistance from both the national government and the city of Munich, the museum project was soon brought to realization.

The collections were housed for many years in the old building of the Bavarian National Museum, but in 1911 the Insel in the River Isar was granted to the museum by the city and carefully prepared plans for a large and comprehensive set of buildings were finally developed in a scale model.

The cost of the new building before its erection was estimated to be about 14,000,000 marks, to which sum the city of Munich expected to contribute 1,000,000, the Bavarian government 2,000,000, the German Empire 2,000,000, and German industry more than 2,000,000. In addition German industry had expressed its readiness to promote the building of the museum by donating various building materials and by undertaking extensive building and installation works either without compensation

[1] The Deutsches Museum is referred to in these pages by the untranslated title by which it is universally known.

Deutsches Museum. View of new building.

or for a part of the net cost. The German railroad administration granted free transportation for all supplies for the museum building.

The buildings, which are of reinforced concrete, were virtually completed in 1913, but owing to the World War the actual task of removing and installing the collections was not begun until 1922. With the limited resources at hand, the task of moving the collections is a slow one, but it is expected that they will be entirely installed in the course of the year 1925.[1]

The new building, as shown on the plan, consists of a series of separate halls, each of which is devoted to a particular division of industry. Each section has been designed with reference to the type of collections to be accommodated and every effort has been made in the architecture of each hall to create an atmosphere appropriate to the exhibits to be installed. The floor space of the exhibition halls will total over 250,000 square feet.

The administration of the museum is under the honorary presidency of the German Chancellor, the German Minister of the Interior, the Bavarian Minister-President, and the Bavarian Minister of Education. There is a Board of Directors which might better be called an advisory council, consisting in 1923 of 102 members, of whom 63 were appointed by the German and Bavarian governments and by technical and scientific societies, and 39 by a so-called General Committee for a period of three years.

The General Committee numbers 575 members, among whom are the foremost representatives of German science, technology, and industry. The members of this committee assist in all important questions and problems with their counsel and cooperation. The Board of Directors or Advisory Council meets once a year. The

[1] The formal opening of the museum in its new home occurred on May 6, 1925, the eightieth birthday of its founder, Oskar von Miller.

General Committee functions through consultation with individuals.

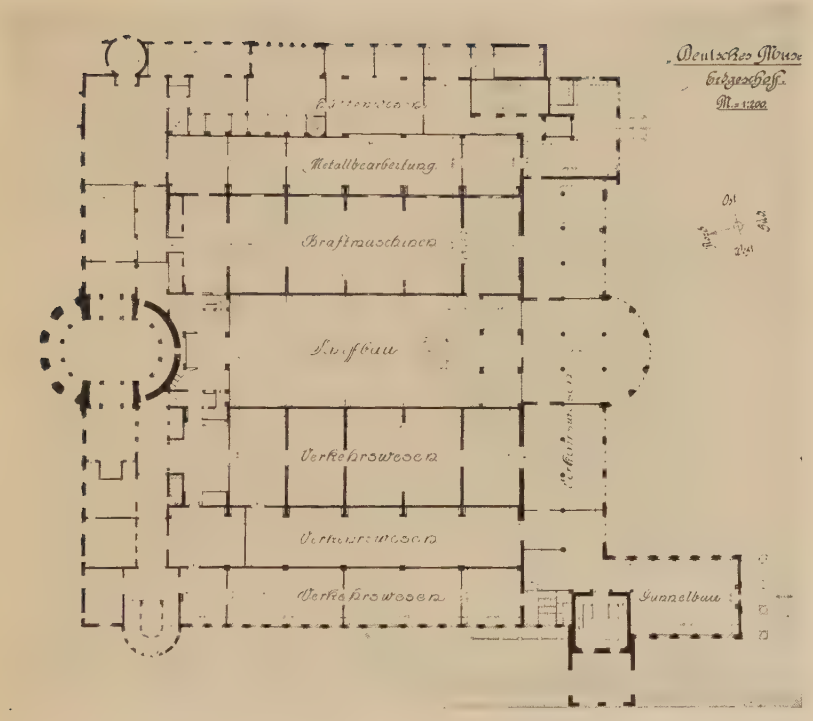
The Executive Committee, upon which falls the actual business of administering the affairs of the museum, consists of Dr. Oskar von Miller, the founder, Privy Councillor Dr. W. von Dyck, and Dr. Georg Kerschensteiner, professor at the University of Munich.

The museum organization is divided into the following departments: administration, business office, new building, science, technology, industry, library and workshop.

The number of officers and employees in 1923 was 105. Among these were ten heads of departments and technical divisions; twenty-five engineers, architects, technicians, and draftsmen who assist in the development of the collections as well as in the completion of the new building and its arrangements, also nine business employees who attend to the current bookkeeping, accounts, etc., and fifty-nine guards who, with two supervisors, care for the museum and visitors.

The collections are classified in the following divisions and groups:

1. Mining, Smelting and Metal Working
   - Geology, mining construction, ore, salt and coal mining
   - Mining machinery
   - Metallurgy
   - Iron production (cast iron, mild steel, crucible steel)
   - Metal working (casting, forging, pressing, rolling, machining)
2. Prime Movers and Transportation
   - Man power motors
   - Wind motors
   - Hydraulic motors
   - Steam engines
   - Gas and oil motors
   - Sleighs and wagons



Deutsches Museum. Plan of new building.

Bicycles and automobiles
Steam and electric railroads
Road and railway construction
Tunnel construction
Bridge building
Canal and harbor construction
Ship building
Aeronautics

3. Science
   - Time, Space and Weight Measurement
   - Mathematics
   - Physics, telegraphy and telephony
   - Musical instruments
   - History and theory of chemistry
   - Geodesy
   - Meteorology

4. Engineering and Building Construction
   - Building materials
   - Private and municipal buildings
   - Water supply and canalization
   - Heating and refrigeration
   - Lighting
   - Gas technology
   - Electric technology

5. Textile Industry, Paper Industry, Agriculture
   - Spinning
   - Weaving
   - Needle work
   - Paper mills and paper machinery
   - Writing and writing technique
   - Printing
   - Reproductive processes
   - Soil culture and harvesting methods
   - Flour mill construction
   - Dairies
   - Brewing and distilling

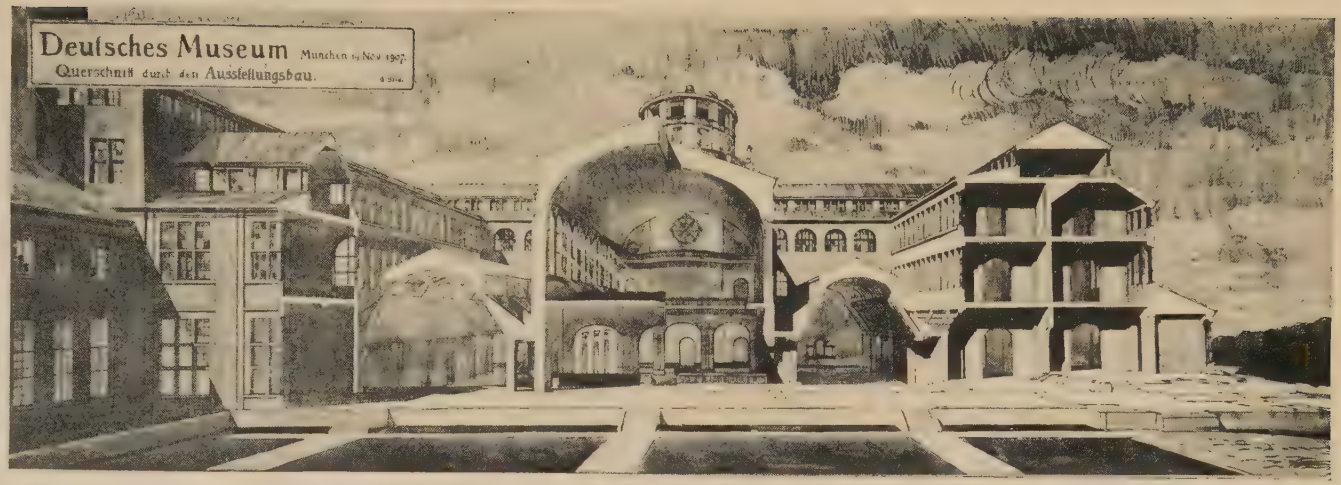
The heads of the scientific and technical departments are men of high scientific and technical standing. This is true also of the engineers and architects who have charge of the special technical groups. The divisional or sectional chiefs are responsible directly to the president. It is their duty to study all available literature on their special subject from the earliest time to the present, and to make out lists of objects desired, together with models, originals or pictures required to illustrate the subject in so far as the space at their disposal permits. This list, after discussion with Dr. von Miller, is sent to the referee expert who is the representative of the special subject on the General Committee. The representative in question either interests himself in obtaining the objects or indicates where they can be obtained. If the objects desired do not exist, sketches and drawings are prepared, or the objects are made either in the museum or outside.

The group engineer sees to the installation and arrangement of exhibits falling within his field. He purchases objects on his own responsibility up to the sum of $25. An assistant group engineer is in charge of the receipt and dispatch of objects.

One of the features of the Deutsches Museum is a Hall of Fame which occupies a prominent place at the entrance of the new building. Here is perpetuated the memory of the most eminent German scientists and technicians. Bas relief portraits of Fraunhofer, Gauss, Leibnitz, Otto v. Guerike, Siemens, Krupp, Robert Mayer, Helmholtz, Bunsen, Liebig, Kepler, Gutenberg, Reichenback and Borsig now adorn the hall. On the walls are a collection of letters, drawings, and manuscripts of famous scientists and technicians of all times and countries.

Included in the museum is a reference library containing about 100,000 scientific and technical works. Some 12,000 books are presented to the library each year.

Throughout every effort has been made to display



Deutsches Museum. Sectional view of the new building.

material to the best advantage. The composition of walls, floors, cases, etc., is made subservient to the main object of drawing attention to the objects exhibited. A large percentage of apparatus in the collections is in working condition. Many of the models are connected with electric motors, and may be actuated by visitors or guides.

All the processes of industry and methods of mining and transportation have been studied so as to find their important and significant features and to make these clear to the visitor. The typical method that is pursued is to illustrate the development of every art by first showing its primitive beginnings, either through actual apparatus, models or representations. The simple ideas thus embodied can be easily grasped. From this starting point the museum shows in sequence the important progressive steps that have taken place. These advances have sometimes been very slowly made,—perhaps with a lapse of centuries between. The different stages are illustrated and the principles and facts involved are further made clear by every resource of diagrams, plans, colored representations, statistics, and descriptive labels.

A characteristic instance that well illustrates this method is the case of the textile processes. First of all is shown a figure of a woman spinning thread with a simple top spindle from crude wool or flax held on a distaff under her left arm. Following this come the hand spinning wheels, one of which is the high wheel used for wool. This wheel requires a forward-turning of the wheel in order to twist and pull out the fibre running from the spindle to the hand, then a stop and a further movement to wind up the twisted thread on the spindle. The next step is shown by the spinning jenny of Hargreaves who first arranged a machine for multiple spinning which evolved into the mule spinning frame of today operating exactly as did the old high wheel with

one motion to pull out and twist the thread, then a stop, and a further motion to wind up the thread on the spindles.

The low or flax spinning wheel, developed in Europe in the early part of the sixteenth century, was an ingenious device which allowed the twisting of the thread and the winding up of the same on the spindle or bobbin through one continuous rotating movement. The evolution of this wheel, first into Arkwright's water frame, next into the power flyer spinning frame, and finally into the ring spinning frame of today is shown in a progressive series.

The physical and chemical sciences that underlie modern technical and industrial methods receive considerable attention in the Deutsches Museum. The fundamental conceptions in these sciences are presented objectively either through models, diagrams, or charts, but, always in close relation, are found the practical applications of the sciences as embodied in modern invention and technical methods.

Geology is a case in point. Sections and geologic maps that bring out clearly the nature of the earth's crust are followed by the group on mining. There the simple appliances and methods of early times in the search for useful minerals are exhibited. Paintings and models show the construction of mines from which different ores, coal, and salt are obtained. Primitive methods of gold washing are also shown. The development of drills, conveying plants, ventilating and pumping apparatus are illustrated from the oldest machines to the modern apparatus of today worked by steam or electricity.

In addition three different kinds of mines—coal, salt, and metal—are shown by full-sized actual shafts, drifts, and galleries excavated and built in the basement of the museum building.

Following mining comes a section on the metallurgy of iron. This section is introduced by a large wall paint-

Deutsches Museum. Model of first Bessemer plant in Germany.

ing giving a schematic survey of the entire field of iron and steel production.

The evolution of the blast furnace for the production of pig iron with its auxiliary equipment, such as coke ovens, hot blast stoves, etc., is indicated by models and pictures. In the same way the old and the modern processes in the manufacture of wrought iron, both directly from the iron ore and indirectly from pig iron, are presented. An old-fashioned German bloomery dating back to the early nineteenth century is installed in this section together with models of old and new puddling furnaces.

Next come models of the first Bessemer and Siemens-Martin plants in Germany. These are followed by an exposition of the manufacturing of crucible steel, by means of a sectional model of a crucible furnace from the year 1811 and a model of a modern crucible furnace. Converting and annealing furnaces are also illustrated by models and drawings as well as the new electric furnaces.

In the next section the working and machining of iron is dealt with. The processes of rolling are shown by a model and drawings of an old rolling mill and by models of the various later types, including mills for rolling sheet metal and for armor plate.

In the group devoted to forging, an old forge with implements and forged products is shown in a full-sized reproduction. Water driven and steam hammers are represented by a series of models which include a scale model of the great Krupp hammer of 50,000 kilogram power. A model of a forging press to operate under pressure of 3,000,000 kilograms also finds a place in this section.

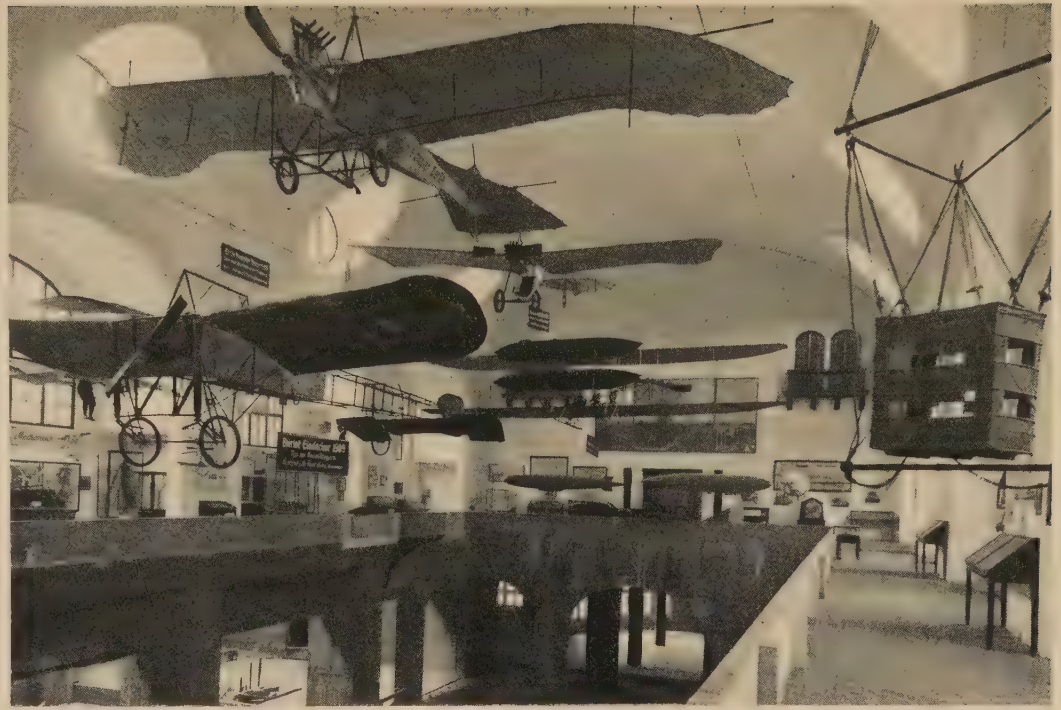
The Division of Transportation is a very important feature of the museum. In the old building both land and water transportation were very fully developed. Land transportation was illustrated from primitive vehicles drawn by men and animals to the most modern

types of motor cars. The technical evolution of railways was shown at much length. A full-sized working reproduction of the "Puffing Billy," a locomotive of 1813, in the Science Museum, and Stephenson's Rocket are a few examples of the many that tell the story of development in this field. The history of electric railways was also fully told. This group contains the original of the first electric locomotive by Werner-Siemens of the year 1879, followed by models and actual examples exemplifying the growth of electric railways since that time.

Water transportation is illustrated by means of models of the most primitive types of log boats and canoes, Phœnician ships, Greek triremes, and mediæval galleys up to elaborate sectional models of great steamships of today. The walls are adorned with copies of Egyptian and Assyrian paintings showing types of early craft. The evolution of the screw propeller is depicted in a series of thirteen full-sized specimens. Models of docks and river shipping follow, together with a relief plan showing the layout of a harbor with buoys and lighthouse.

In the late fall of 1923, the installation of the aeronautical section in the upper portion of the transportation hall of the new building had been practically completed. The exhibit has been developed in an exceedingly interesting fashion, and is admirably displayed. It starts with examples of skeletons and stuffed specimens of great flying birds and close at hand is a cyclorama showing bird flight. The first alcove is to be devoted to models and data bearing upon the science of flying. Then come models and illustrations showing the early gas-filled balloons of Mongolfier and others.

Along the gallery rail are sloping cases which contain engravings and wood cuts bearing upon the history of aeronautics. Several of the alcoves are built with recessed spaces with glass fronts in which are placed scenic panorama made to scale illustrating various important episodes in the history of flying.



Deutsches Museum. Hall of Aeronautics.

Paper manufacture is explained both as to processes and materials, in all its details. To the evolution of writing and printing, considerable space is devoted. A monk's cell of the mediæval period as well as Gutenberg's printing room are both reproduced. Special attention is given to the most modern methods of color printing.

Agriculture is considered from the side of processes and implements. The evolution of the plow and other agricultural implements is vividly depicted, both by full-sized examples and by many models arranged in scenic groups. A small cinema room is provided for developing pictures showing plant growth.

One large hall of much architectural beauty is devoted to the development of musical instruments. Wind instruments are shown here in historic forms, and their method of action brought out by demonstration. Here the simple clavichord and spinnet evolve before one's eyes into the grand piano of today.

A description of the Deutsches Museum cannot close without reference to the extremely interesting planetarium showing the movements of the sun, moon, planets and fixed stars as viewed by an observer on the earth. The planetarium consists of a white surfaced concrete dome ten meters in diameter upon which the heavenly bodies are projected as spots of light by a remarkable apparatus made by Zeiss of Jena. By means of this apparatus the fixed stars of the heavens up to the number of 4,500 are represented in varying intensity. Even the milky way is indicated.

The whole apparatus revolves about an axis corresponding to the polar axis which is approximately 42 degrees for the latitude of Munich.

The chief purpose of the planetarium is, of course, the representation of the movements of the sun, moon and planets. The relations of these bodies are reproduced in all their seasonal phases and regulated as to

rate of movement through a motor drive system to almost any extent. To illustrate the daily cycle the whole system is turned about the polar axis. Speeds can be so regulated that a day may be made equivalent to 4½ or 2 minutes or even only 50 seconds. The movements of the sun, moon and planets can be controlled separately from that of the fixed star heaven. By these means the celestial events of a whole year may be reviewed in 4½ minutes or 50 seconds, or even 7 seconds, and the movements of the planets traced in an extremely vivid fashion.*

The attendance at the Deutsches Museum is very large and before the war was increasing yearly. About 1910 it exceeded 300,000 a year. All pupils in the public schools of Munich over 10 years of age are required by the educational authorities to visit the museum once a year under guidance.

Visits of two kinds are arranged by the museum:

1. Visits personally conducted by the engineers of the respective groups. These visits extend over some one section of the museum, embracing one to three halls, and take place daily except on Sundays and holidays at 8:15 p.m.

2. Special personally conducted visits for single visitors or groups. The duration of the conducted visit is about 2 hours. These visits may be applied for at any time between 9 a.m. and 1 p.m. and between 2:30 and 6 p.m.

Public lectures on special subjects, often given by a member of the General Committee, were formerly conducted. Frequent evening lectures, aimed at the working man type, were also given by group engineers on a particular subject in their own group.

Before the war these lectures were widely advertised and posted throughout the schools and the headquarters of the trade and technical societies of the city.

* A summarized list of the material included in each division and group of the collection as arranged in the old buildings is given in Appendix 2.

Deutsches Museum. Hall devoted to methods of soil cultivation.

A fund contributed by individuals has been established to facilitate the bringing of students and workers from schools and industrial establishments in different parts of Germany to the museum. They come from Realschulen, Gymnasien and factories. Some 300 students thus yearly spend four days at the museum. The money is given to the schools which select the individuals, two or three from each institution. Each student makes a report to the school on the results of his study of the museum, a copy of which is sent to the museum. For unusually excellent reports diplomas to the number of six or eight are awarded.

The museum is also used as a center by scientific, technical, and industrial societies for conferences or congresses.

Before the war the cost of maintenance was about 400,000 marks ($100,000) a year. To defray these costs the Bavarian government and the German Empire each contributed 50,000 marks, and the remainder was covered by admission fees and interest. The city of Munich supplied heating and light free of charge.

Membership in the museum may be acquired by corporations, societies, firms, and individuals:

1. By subscribing a fixed sum of at least 200 marks
2. By paying a yearly subscription of at least 6 marks

The number of members in 1923 was about 6,100.

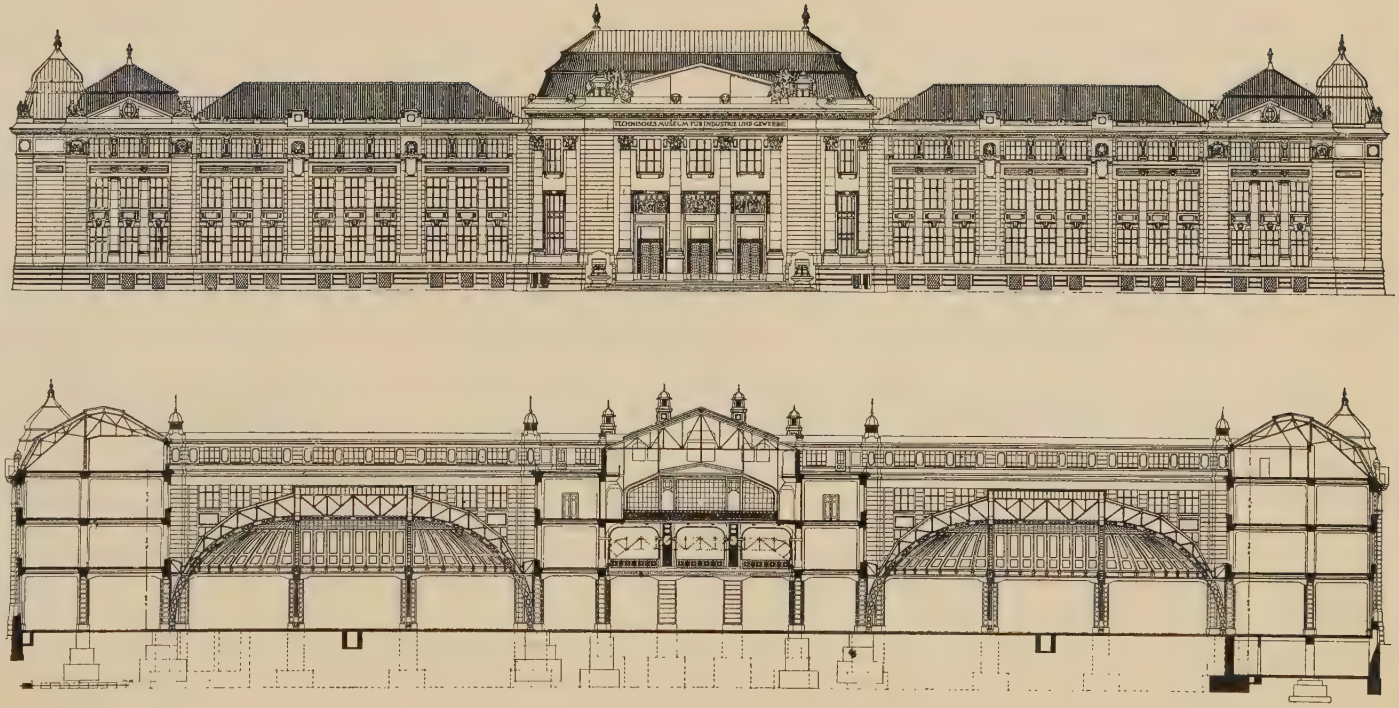
The price of admission before the war was 20 pfennige for each person. Tickets good for one year cost 3 marks. Students' tickets for scholars accompanied by teachers good for the usual hours of admission, with the exception of Sundays and holidays, were sold at the price of 1 mark for 15 tickets.

For the year 1913 the total receipts were 611,888.88 marks. The ordinary expenditures, including salaries and wages for operation, maintenance charges, and purchases of objects to supplement the collections, were 256,516.13 marks. The extraordinary expenditures, in-

cluding salaries and wages for initial arrangement of displays, expenditures for structural arrangements, and purchase of objects in the groups were 84,094.60 marks, making a total of expenditures for the year of 340,610.73 marks.*

To sum up: The Deutsches Museum has had, from its inception, a purely educational aim and an educational policy. Its organization, collections, and methods of display have all been so developed as to forward this educational purpose. Material has not been collected and installed to make a storehouse of industrial apparatus and models, but to illustrate significant inventions and important phases of scientific and industrial progress. The only question that arises when the museum is viewed from this angle is as to whether it has not somewhat over-reached itself in the matter of size and complexity. On the other hand, the displays have been most effectively developed to reach popular comprehension and to impart vivid impressions of the high spots in the history of science and inventions. All the secondary activities of the museum are admirably adapted to further the main educational purpose.

* The financial reports for the year 1913 are presented in Appendix 3.



Technical Museum, Vienna. Elevation and section of building.

CHAPTER V

THE TECHNICAL MUSEUM—VIENNA

(Technisches Museum für Industrie und Gewerbe in Wien)

THE technical museum in Vienna, though long ago conceived, has only recently come to realization. An important step was taken after the International Exposition of 1873 in an attempt to bring together material exhibited there illustrating Austrian industry and inventions. While it was found impossible to retain all this material, a certain amount became the basis of the Technologisches Gewerbe Museum. Subsequently there developed independently a Post and Telegraph Museum, a Historical Museum of Austrian Railways, and an Industrial Hygiene Museum. The movement took final form in 1908 on the occasion of the sixty-year jubilee of the Emperor Franz Joseph. The large trades exhibition, first planned, became on second thought a permanent museum for the education of the people.

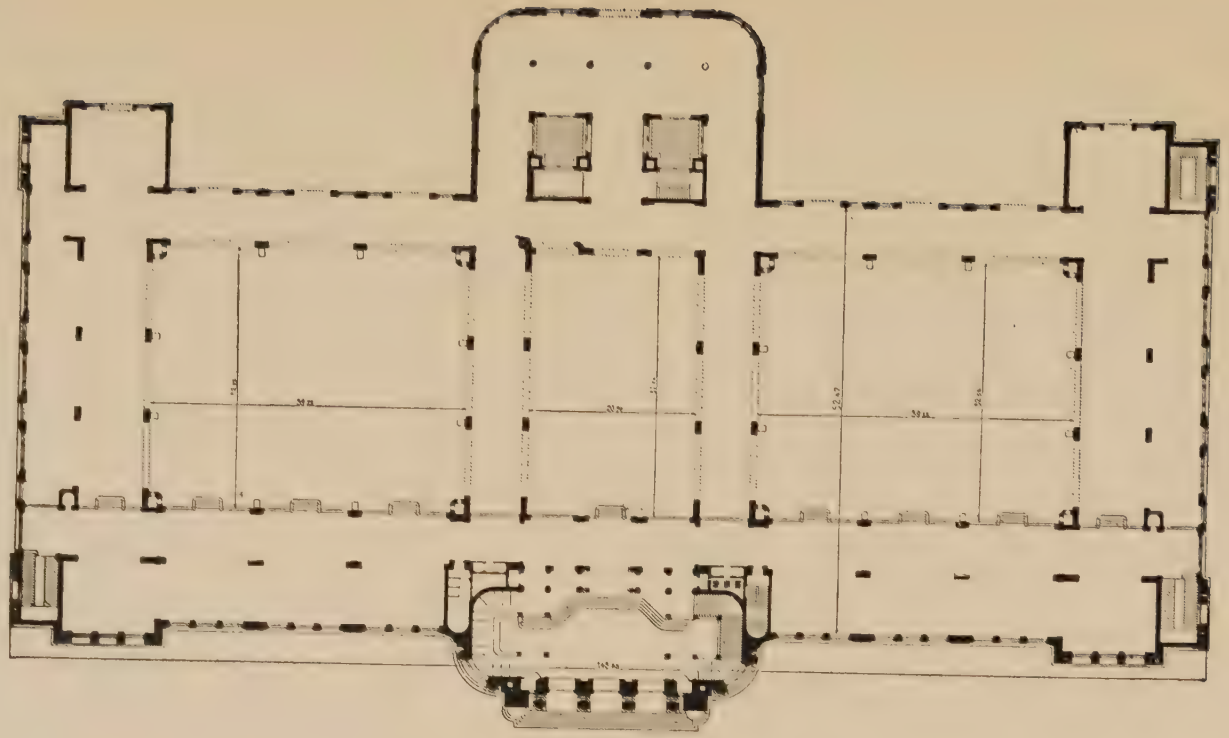
In 1909 an imperial decree was issued dealing with the organization and purposes of this national technical museum. A report made in 1914, shows that an organization of technical advisors called a Kollegium had been developed consisting of 875 members divided into seventeen technical groups comprising agriculture, mining and smelting, iron and metal industries, machine construction, electrotechnics, transportation and communication, the scientific foundations of technology, chemical industries, industries dealing with food and table luxuries, graphic arts, fiber industries, clothing

industry, stone and earth industries, building construction, sanitary science, safety appliances, fire protection, and life saving methods.* These groups had, after frequent conferences, developed a comprehensive scheme as to scope and plan. Agreement had also been arrived at assuring the combination of the collections above described into a technical museum, and building plans had been made. The building was erected in the years 1909 to 1913. The collections were installed between 1913 and 1917, and the opening of the museum occurred in May, 1918.

Both plan and construction of the building are noteworthy. They are in sharp contrast to the building of the Deutsches Museum in that the ground plan represents one large space including the entire building area and no closed exhibition rooms are involved in the structure of the building. The plan divides into a central and two side halls, lighted by dome-shaped glazed roofs. Surrounding these bays are three stories of galleries lighted from the outside excepting only the inside portion of the first gallery about the central hall. The outer walls are constructed of brick with an ornamental facing. The roof and floors are reinforced concrete. The skylights in the roofs cover an area of 2,100 square meters (22,470 sq. ft.). The floor area for the exhibition rooms is 15,570 square meters (167,000 sq. ft.), of which 2,570 square meters are contained in the floor area of the three main halls. The main passages in the exhibition rooms make a total of more than four kilometers in length (about two and a half miles).

Great attention has been paid to the problem of natural lighting and in the design eventually developed sufficient daylight was secured throughout all points in the building. The museum is provided with a moderate amount of artificial lighting but is not planned for evening display.

* The complete organization of these groups is given in Appendix 4.



Technical Museum, Vienna. Plan of first floor.

The building cost about four million kronen ($840,000) and the grounds have a value of about one million kronen ($210,000). From the above figures it is calculated that the capital value of one square meter of floor area in the exhibition rooms represents 322 kronen ($67.62).

The effect of the museum building is exceedingly agreeable to the visitor, giving him, during his stay upon the first floor, a constant impression of the sweep and extent of the collections. The spaciousness of the large halls is highly impressive; the general scheme of arrangement is easily grasped; lines of travel are simple; and all portions of the building are convenient of access.

The structural elasticity of the building is an important advantage. The absence of closed halls facilitates future modifications and changes in the displays.

Statutes governing the organization of the museum were issued by the Federal Ministry for Trade and Commerce on December 30, 1921. The purpose and arrangement of the museum were therein set forth as follows:

A. The museum is to represent the development of industry, to promote technical progress, and to be a place of education for the entire people. This purpose is served by the following arrangement:

1. The exhibit collections of the museum.
2. A technical library and archives, together with a collection of photographs and films.
3. Conducted tours and lectures.
4. Scientific papers and publications of a technical kind.
5. Technical department exhibits.
6. Other measures and arrangements which are calculated to serve the purpose of the museum.

The organization was indicated as follows:

B. The Technical Museum is a Federal institution and is under the Federal Ministry for Trade and Commerce.

C. The museum management consists of a Kuratorium (Board of Managers), a Board of Directors, and a Director of the Museum.

The Kuratorium consists of the president and thirty members who are named by the Federal Ministry for Trade and Commerce.

The chief functions of the Kuratorium are to render opinions to the Federal Ministry regarding the organization of the Technical Museum and its arrangement and the approval of the annual financial estimates of the museum. They are summoned to meet when needed, but in any event at least once a year.

The Board of Directors consists of the president, the three vice-presidents, and five members who are appointed by the Federal Ministry for Trade and Commerce on nomination by the Kuratorium from among its members. The Board of Directors submits proposals to the Kuratorium regarding the operation of the museum and its arrangement, and may make suggestions to the Kuratorium concerning matters which fall within the sphere of activity of the latter body.

The Board of Directors reports to the Federal Ministry in regard to museum matters so far as they are not reserved to the Kuratorium, especially in regard to proposals relating to the staff. Under the supervision of the Federal Ministry they conduct the business of the museum in its administrative and financial aspects and supervise the business administration of the director.

The Federal Ministry for Trade and Commerce appoints an expert of technical qualifications as director of the museum, on nomination of the Kuratorium. The

Technical Museum, Vienna. Vestibule.

director, who has charge of the immediate management of the museum, is provided by the Ministry with a suitably qualified staff; he attends to the current tasks of administration and, subject to the supervision of the Board of Directors, directs the operation of the museum. *

There is also a large body of technical advisors called a Fachkonsulenten who select objects for the museum collections and prepare for their acquirement either as gifts, loans, or by purchase. The instructions issued to this body emphasize the necessity of selecting only typical and significant material. The library is relied upon to furnish documentary records that will fill out the history of technology, beyond the scope of the collections.

The total staff of the museum formerly numbered 107, but by 1923, because of economic stringency, had been reduced to 37. Among these were included the director, three departmental engineers, three draftsmen, one superintendent of buildings, one assistant superintendent of buildings, one accountant dealing with museum contracts, two clerks, two keepers, one night keeper, five cleaning women, twelve workmen and guards. The normal staff includes heads for each of the following departments: mechanics, electricity, building, hydraulics, mining, chemical industries, science, and transportation.

The arrangement of the material in the Technical Museum is extremely effective. As in the Munich museum, every effort has been made to bring out the important factors entering into the industrial life of today; and, as at Munich, the historic evolution of processes and machines has been largely relied upon to develop this comprehension.

Vivification of the displays of the museum has been a dominant aim. Thus through carefully developed methods of presentation it is believed that even a layman may be enabled to grasp the construction, the mode

* The Statutes are given in full in Appendix 5.

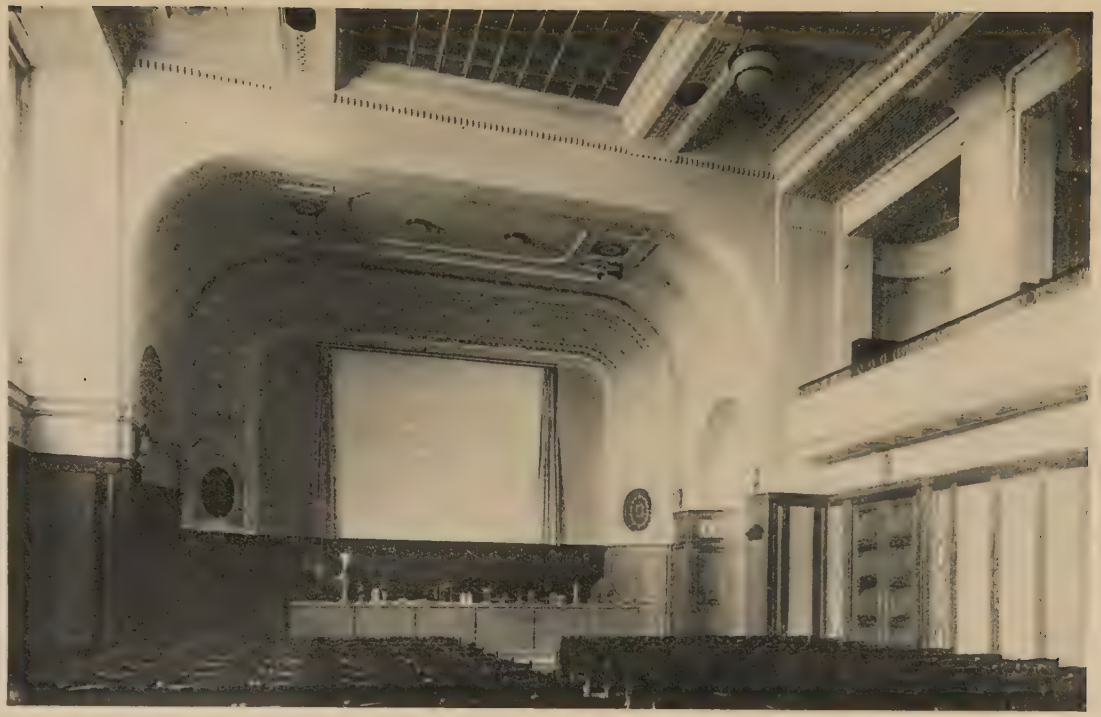
of operation, and the purpose of technical apparatus. Much importance is attached to actuation of the models. Reference to this method is made at some length in the directions to the technical advisors as follows:

"The interest which, as has been discovered by experience, proceeds from observation of processes, must have great attention paid to it from the point of view of museum technique. The presentation of actuated mechanical machines and models must therefore be striven toward with all possible emphasis as the educator's most effective means. The actuation of smaller pieces of apparatus is best effected by means of manual operation. For power operation of larger objects there is available in the museum building electric current, namely direct current of 220 and 440 volts as well as alternating current of 220 volts and 48 cycles and also illuminating gas and water under pressure."

"The wiring system was installed in the museum building in such a way that the possibility of connection for objects capable of operation is afforded at every point of the collection rooms. Abundant provision has also been made for the electric illumination of panoramas, transparencies, microscopes, and similar arrangements."

Special stress has also been laid upon the explanation of objects difficult to understand by means of sectional drawings and legends which, omitting all secondary matter, bring out prominently the essential features of the objects. In these drawings structural materials are indicated by identical colors. Inscriptions and legends are made extremely concise and care is taken to make them distinctly legible. For this purpose a simplified, clear script in block character with good rhythmic qualities is employed.

In the vestibule is displayed a plan of the building upon which is indicated the distribution of the collections. At one side of the vestibule is a pictorial chart



Technical Museum, Vienna. Lecture hall.

in water colors setting forth the development of water transportation, bridges, buildings, and arms in the primitive, mediæval, and modern stages. Along with this, in sloping cases, are shown synoptic displays of grinding, cutting and boring tools, and knives and files in these three stages.

On the other side is a similar pictorial chart indicating the application of energy as represented in these three eras in regard to pumps, saws, hammers, and prime movers. Accompanying this are synoptic displays illustrating fire-making, drilling tools, hammers, axes, piercing tools, and saws.

In the central hall are displayed historic prime movers, often accompanied by models. These include a very early original wooden turbine wheel from the Balkans and a model of an Egyptian windmill. Many of the models are operated by hand and others by compressed air. The prime movers culminate in a Diesel engine of 80 h.p. operated by an electric motor. The development of bicycles, road vehicles and automobiles is also exhibited in this hall. The action of typical automobile engines, sectioned both as regards cylinders and valves, may be studied.

In the wide hall at the left is the railroad museum showing the development of Austrian railroads by actual examples of locomotives, railway carriages, signal systems, and other railroad apparatus from the period of 1840 up to our own day.

At the end are placed working models of early electric tramways, together with modern examples. In this space are also found some examples of historic machine tools. In the basement at this end of the building are types of early rails and road beds. Models, drawings, photographs and diagrams are shown illustrating tunneling and drilling. Excellent scenic panoramas of Austrian Alpine railroads are also here displayed.

The front aisles contain models of railroad bridges and stations as well as relief models of the Alpine regions crossed by the Austrian railways. The original drawings of the screw propeller by the Austrian claimant for the invention of this device, Joseph Ressel, are exhibited here. This section also contains models of marine engines arranged to be actuated, and models of docks. In the front aisle to the right are models of warships and torpedoes, among which is a sectioned Whitehead torpedo. Here, too, one may inspect models of steamships and one most remarkable sectioned model about 15 feet long of the former Austrian warship "Viribus Unitis." This model required the work of several men for a period of three years.

Further on is found a section on metal working which includes a very fine historic collection of locks and keys presented by the Locksmith Guild; beyond, the beginning of a section on mining and smelting which includes a reproduction of a country smithy including water wheel and helve hammer. In this corner of the building a large wall painting portrays the prehistoric flora from which coal has been made. Directly below are stairs leading to the basement where a coal mine with shafts and galleries and figures and apparatus illustrate the processes of coal mining, in much the same way as in the Deutsches Museum.

Returning to the first floor, we find the division of agriculture in which small and full-sized models of agricultural implements are shown, arranged, wherever possible, so as to be capable of operation. Complete reproductions of an old brewery and corn mill are here installed.

A model of a cable mountain conveyor is exhibited and, close at hand, a model of a lumber mill with seven saws and an engine that can be set in motion. A full-sized example of the latest type of gang saw for

Technical Museum, Vienna Railway Hall

a lumber mill is arranged to operate in actual cutting of logs.

In the domed hall on the right, the smelting and working of metals are illustrated. Here an old Styrian refinery has been installed with original water wheel and helve hammer.

In the same section is to be found a full-sized Bessemer converter with the lower part sectioned and sealed with glass. The lower portion contains water and a very realistic impression of the operation and changes in the action of the converter is obtained when air is forced through the inlets and the changing temperature colors are reproduced automatically by electric light manipulation. There is also a sectioned model of a blast furnace in which the operation is illustrated in the same fashion as in the case of the Bessemer converter.

The story of iron working begins with an old forge for making scythes which has been rebuilt in the museum. Models of rolling mills, helve hammers, and the great hammers of Krupp are shown with operating attachments.

Another section of this hall is devoted to electric technology in which examples of dynamos, motors, accumulators and electric lighting apparatus are displayed. Gas technique also has a space, in which the evolution of lighting apparatus and the use of gas in homes and in industries is set forth.

A fine lecture room on the second floor equipped with a demonstration table with appurtenances for physical and technical demonstrations as well as with projection apparatus for still and motion pictures accommodates an audience of three hundred.

The gallery floors afford admirable opportunities for well-lighted alcoves which, though varying in size, are usually about 15 x 12 feet in dimension.

On this floor is the section called "The Scientific Foundations of Technology." This contains first of all a collection of a historic physical apparatus which is fol-

lowed by apparatus to illustrate physical laws. Many of the demonstrations can be operated by visitors. The booklet, however, advises those who are interested to apply to the keeper, who will make the demonstration. There are many diagrams presenting electrical and electro-chemical phenomena. One room contains a Roentgen-ray apparatus and a room with Geissler tubes; further on are chemical laboratory tables available for demonstrations. At the end is a reproduction of an alchemist's room of the middle ages.

The chemical industries are well represented by models, diagrams and descriptive posters.

In the section devoted to food production a very large model of a sugar mill shows the machinery in operation. The processes of brewing are embodied in an elaborate model. In connection with the former an old stone brewery from Carinthia, operated until the beginning of the present century, is used to show the very ancient method of brewing "stone beer." An old grinding mill from a Benedictine abbey in Styria built in the late eighteenth century is found close by.

Paper making is depicted, first by means of a model of an old paper mill, and then by a very complete model of a modern paper mill about 16 feet long constructed to one-tenth scale. The various uses of paper are also indicated.

The exhibits devoted to printing and the reproductive processes are very extensive. Typical examples of printing and color processes are shown in the windows as transparencies.

The textile industries are presented in their historic development. The hand spinning wheel is shown in its evolution into the full-sized operating mule spinning machine and the hand loom as the germ of the modern machine loom.

Shoe making, the making of costumes, and the production of hats, are also illustrated. In this latter section

Technical Museum, Vienna. Figure of miner undercutting coal.

is a very attractive reproduction of an old Viennese hat maker's shop of the beginning of the nineteenth century.

In this gallery are models and diagrams of building construction, hydraulic works, and canal construction. Water supply and sewage is also represented here. The display contains a section of a modern city street showing all the various underground conduits devoted to water supply, sewage, gas and electric supply. The cement industry, ceramics, and glass also have a place here as well as weights and measures. In this last connection is shown the uniform standard weights and measures introduced in the Austrian monarchy in the year 1756 during the reign of Maria Theresa.

In the upper part of the central domed hall and in the adjoining gallery full-sized examples and models show the development of aeronautics.

The second range of galleries includes displays illustrating water supply and conservation, organization of technical plants, industrial hygiene, fire protection and life saving, theater and music technique, postal museums, surveying, and bridge building.

The third range of galleries is devoted to the executive offices, working laboratories, studio, and workshops. In the studios displays are arranged and developed in consultation with the technical advisors. In the laboratory, experimental projects in natural science and technology are prepared and tested. The workshops include plaster casting facilities, a joinery shop, and a book bindery.

The cases used in the Technical Museum deserve special notice. They are built of a skeleton frame of metal with panels filled with a composition of asbestos and cement called "eternite." This construction has proven cheaper than wood and is fire-proof.

The attendance at the museum has of course been greatly prejudiced by the severe economic conditions prevailing in Vienna since the war. It has, however, amounted to over 2,500 visitors per week.

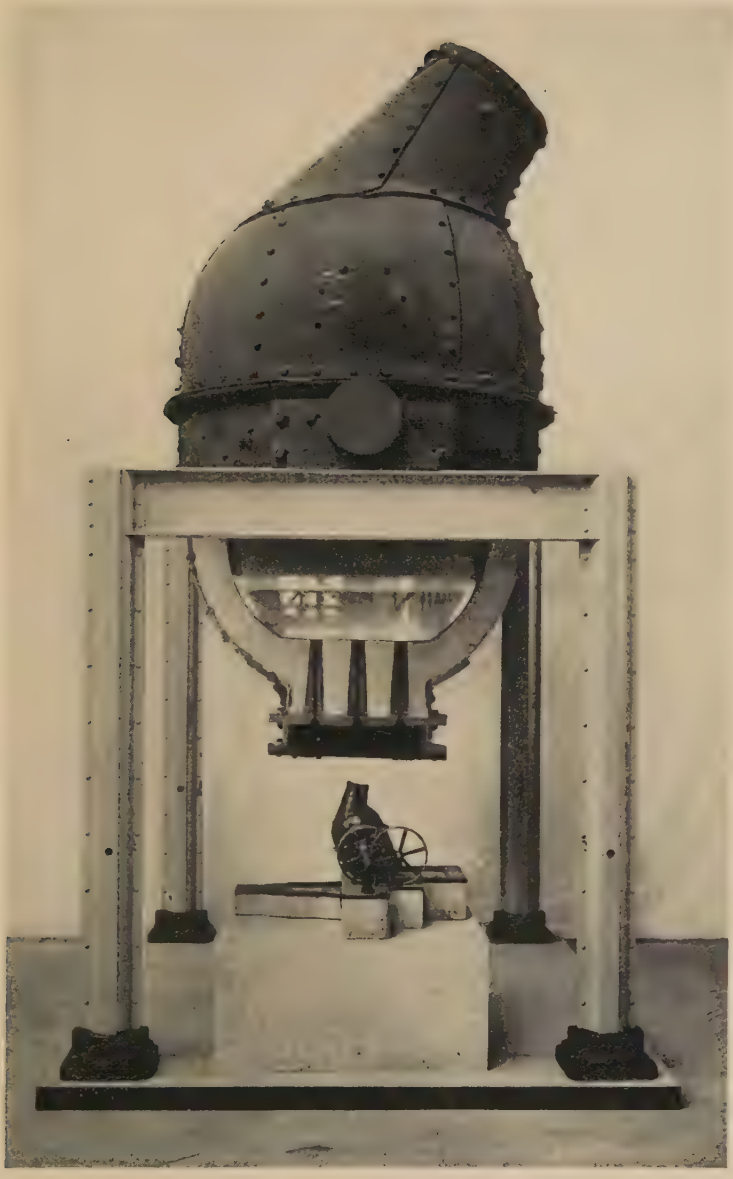
Every child from 8 to 14 years of age in the public schools must visit the museum once a year under the regulations of the school authorities. Wednesday is set aside as their special day.

Lectures are given every Sunday in the lecture room on the history of technical developments. Motion pictures are made frequent use of to illustrate technical and industrial processes. Such presentations at times precede conducted tours to special departments of the museum. Once a month a lecture is devoted to new inventions.

A hall is provided in the building for temporary technical exhibitions. It is the hope that later on this hall will be replaced by a special exhibition building.

The support of the museum is derived from the Austrian Government and from the city of Vienna. The receipts for 1923 were 708,000,000 kronen ($1,114.30) when the kronen were reckoned at 70,000 to the dollar. This amount included 10,000,000 from the city of Vienna and also 120,000,000 kronen from entrance fees which, under the regulations, it was necessary to turn back to the government. These figures are of course not indicative of the real cost of operating the museum. They are given only to suggest the remarkable conditions under which the Technical Museum and other museums in Austria have been obliged to maintain their existence since the World War.

If we consider this museum from the standpoint of an educational institution, it is difficult to criticize. The building itself possesses many admirable features. The collections have been developed with the greatest care to secure such examples as will best illustrate significant steps in the progress of industry. The principle of selection has prevailed throughout and the danger of too great quantity or complexity has been avoided. On the other hand the art of display has been most carefully



Technical Museum, Vienna. Model of Bessemer converter.

studied and the utmost effectiveness in exposition has been attained. The staff activities of the museum as regards lectures and guides have been admirably organized.

CHAPTER VI

INDUSTRIAL MUSEUMS IN THE UNITED STATES

SINCE the beginnings of human existence, time and space have set bounds to man's attainments. At first with only his slow-moving brain and feeble muscles, the world was that within reach of his arms and his legs. The Greeks recognized these limitations. In their myths the gods abolished time and space. Man has struggled unceasingly towards these gods of his imagination that he, too, might wield thunder bolts and accomplish miracles.

When the first bow was bent, the conquest of space began. When man harnessed the horse or bullock to draw his burdens, he began his age-long effort to utilize other forces to supplement his own. When the first sail was set the world expanded a hundred-fold.

But progress was slow. Up to the last century man had little but his own puny strength with which to rend ore from the earth, to erect his buildings, and to shape stubborn materials into tools and weapons. During this period his achievements were mainly in the way of devices to assist in the performance of his various tasks. Such were the potter's wheel, the high and the low spinning wheels, the hand loom, the printing press, and mechanical powers like the block and pulley, and the wheel and axle.

When he evolved the steam engine, he became a Titan. From that day he has been able to exert the strength of a thousand men to tear into the heart of the earth, to shape and rear great structures of steel, and to draw armies across a continent. He set this new strength to

drive his array of devices and primitive tools, some simply with greater power, others in multiple and at greater speed. Where once all the women in the world save a favored few must needs spin and spin to feed the greedy looms, now a small fraction with the power spinning frame furnish all the thread required for the still more greedy power looms.

Then man found a new force—electricity—that travels with the speed of light; through its aid his dream has well-nigh been realized. He has almost conquered time and space.

He has now learned that added power must come either from new agencies or through the better utilization of the old; hence on the one hand, he pries into nature's secrets to find new forms of energy which may be harnessed into service, and on the other, he devises and invents means of improving the old methods better to serve his ends.

The history of industrial progress is the history of the successes that have been won in the ceaseless struggle to conquer time and space. It is at the same time the history of the achievements by means of which human energy, at first consumed entirely by the struggle for mere existence, has been increasingly liberated for other less material aims. Upon these achievements rest not only the physical comforts and facilities that we enjoy today but in a large sense our spiritual well-being and intellectual development.

The story is one of great cultural significance. It is a record of the victories that human intelligence has won in harnessing material forces to the service of society. Unless the elements of this history are made a part of our common culture, the individual can hardly obtain any true understanding of the social order in which he lives or comprehend even in a limited way the phenomena by which he is surrounded. Furthermore, unless the great mass of our people have some knowledge of the

inventions and methods upon which our industrial order is based, we will lack the maximum stimulation toward further conquests in this field.

We are today one of the foremost industrial countries of the world. Can we afford to omit from our educational program the story of what has made us? We have developed a high type of industrial organization and as a people we are the first to utilize the fruits of new inventions. Shall we leave other nations to grow wise through the study of our achievements and ourselves neglect their meaning and their inspiration?

To tell the story adequately we need the industrial museum.

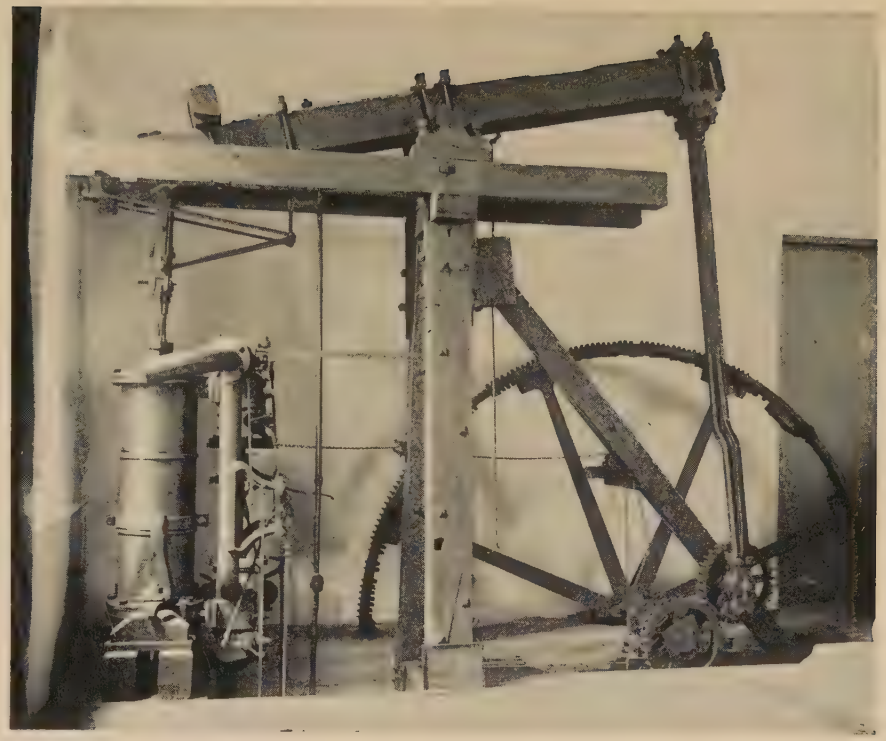
With its great area and numbers of people, the United States requires several such museums in different large centers of population. Great cities like New York and Chicago with varied industries and extensive merchandising interests call for museums of a comprehensive type. Cities like Pittsburgh and Detroit of more specialized industrial character might well develop museums that would first of all reflect the particular industries characteristic of these cities.

The main fields which might naturally receive first emphasis in an American industrial museum of the comprehensive type would seem to be railway and road transportation, iron and steel production, steam and oil engine design, electric inventions, the development of machine tools, various lines of manufacture illustrating quantity production and the use of specialized machines, and agricultural machinery.

Among the departments that would naturally find representation in such a museum would be the following:

I. *Agriculture*

1. Agricultural implements and machinery.
2. Methods of lumbering, saw mills, wood working machinery, forestry conservation.



Science Museum. Watt's first sun and planet engine.

II. *Mining and Smelting*

1. Methods of coal and metal mining.
2. Production of iron and steel.
3. Production of petroleum; methods of refining.

III. *Iron and Metal Working*

1. Casting of iron and other metals.
2. Forging, pressing, rolling and drawing.
3. Machine tools.
4. Stamping, spinning and enameling.

IV. *Prime Movers and Machines*

1. Wind, water, steam, gas, and oil prime movers.
2. Pumps, compressors, and refrigerating machines.
3. Lifting and transporting equipment.

V. *Electro Technology*

1. Sources of current. Action and measurement of current.
2. Generation and distribution of current.
3. Electric lighting and heating.
4. Electric motors.

VI. *Transportation and Communication*

1. Postal, telegraph and telephone systems.
2. Railways and road vehicles.
3. Marine transportation.
4. Aeronautics.

VII. *Chemical Industries*

1. Inorganic.
2. Organic.

VIII. *Agricultural Industries*

1. Sugar manufacture.
2. Flour milling and baking.
3. Tobacco industry.

IX. *Fiber Industries*

1. Braiding and knitting.
2. Spinning, weaving.
3. Dyeing and printing.
4. Leather industry; shoe manufacturing.
5. Paper industry; wall papers.

X. *Stone and Earth Industries*

1. Manufacture of cement.
2. Ceramics.
3. Glass industry.

XI. *Building Construction*

1. Construction methods; heating and ventilation; lighting.
2. Municipal service: water supply, sewage disposal, gas and electric systems.
3. City and district planning.

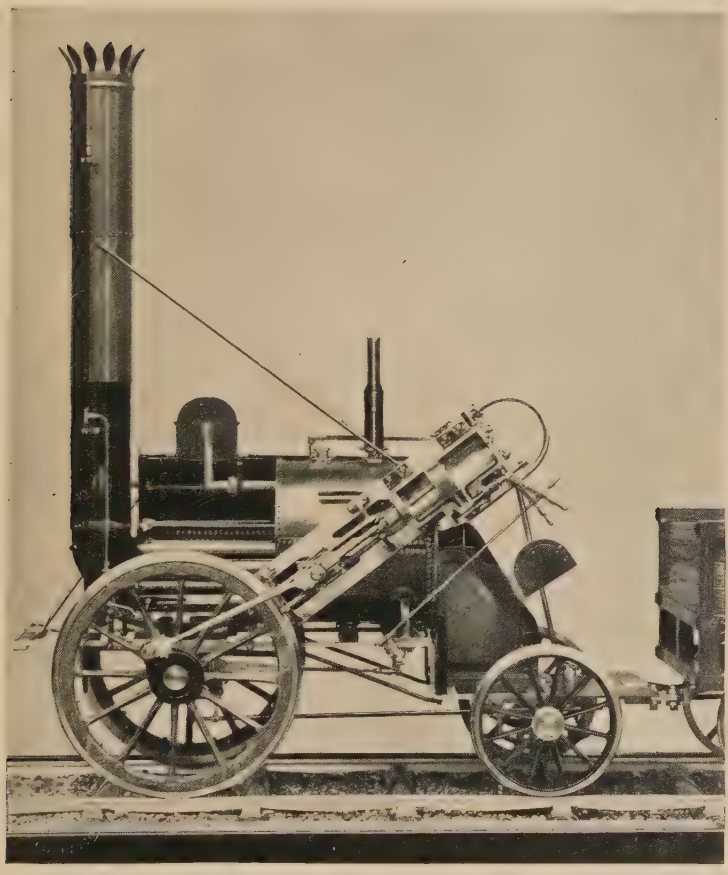
XII. *Graphic Arts*

1. Writing and printing.
2. Type casting and type setting machines.
3. Printing processes.
4. Photography and cinematography.
5. Photo mechanical reproductive processes.

XIII. *Safety and Sanitation*

1. Protective methods applicable in industry and mining.
2. Fire protection.
3. Industrial hygiene.

In the matter of a building for such a museum, a study of the European museums indicates many important merits in the building of the Technical Museum of Vienna. The agreeable quality of the open vistas, the admirable lighting, the elasticity of arrangement con-



Science Museum. Reproduction of Stephenson's Rocket.

sequent on the absence of fixed internal structural walls are all advantages of great importance. The cost of duplicating in New York City a building similar to that of the Technical Museum of Vienna, exclusive of the heating plant, is estimated at approximately $4,500,000.

The administration of such a museum would probably be most effectively accomplished by following the usual American museum practice, namely, that of a lay board of trustees which is responsible for financial and general policies to be carried out by a professional staff appointed by the board. From the economic and social standpoints, it is highly desirable that such museums be recognized as semi-public undertakings, that they be located upon public land and housed in buildings erected by municipalities which contribute toward the expense of maintenance.

An industrial museum, however, needs a multitude of contacts with science, industry and engineering. To secure these it would seem wise to follow the plan of the German and Austrian museums, by associating with the administration of the museum a large body of experts in the various fields represented by its collections. This could be accomplished by the formation of a body consisting either of recognized leaders in the various technical and scientific fields or of representatives named by the various scientific, engineering and technical associations of the country.

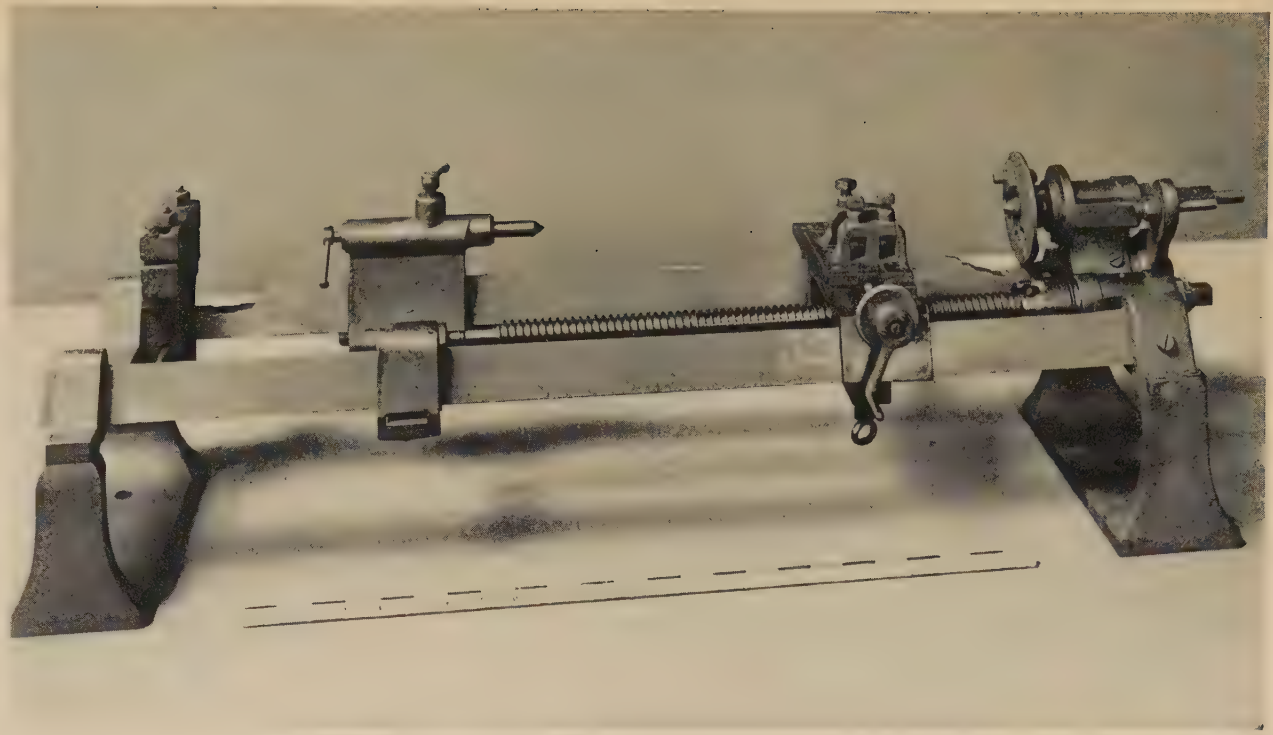
A thoroughly competent professional staff must head the various divisions or sections of the museum. The full plan of the Deutsches Museum calls for five heads of technical and scientific departments and a number of assistant engineers or technicians. The complete scheme of organization of the Technical Museum in Vienna requires seven technical department heads. The nature of the collections and their educational presentation must depend largely upon the quality of the staff. For an American museum of the scope indicated above, it would

probably be necessary to provide a staff organization of department heads or assistant section chiefs as follows:

1. Agricultural machinery, forestry, and wood working machinery.
2. Mining and smelting.
3. Metal working and tooling, prime movers and machine construction.
4. Electrical engineering.
5. Transportation and communication.
6. Chemical industries.
7. Fiber industries.
8. Stone and earth industries.
9. Building construction and municipal supply.
10. Graphic arts.

It would undoubtedly be possible to group these divisions so that only five, six, or seven department heads would be required who, in certain cases, might be assisted by section chiefs.

In the matter of displays, the danger of over-weight should be kept in mind from the outset; no collection should aim to comprehend all elements in its field. Such an attempt would defeat its own ends. A collection even approaching completeness would be at once too large to allow of study by the layman, too great in mass of material to allow the assimilation of the comparatively few significant ideas which can be absorbed, and at the same time too expensive to house and maintain. The only way in which a museum can be prevented from becoming an unwieldy storehouse of steadily accumulating material is by constant emphasis from the beginning on the educational aim as controlling both the amount and nature of its collections and their display. Moreover, the educational purpose must be in mind not only in planning, but in developing the museum. Constant



Science Museum. Maudslay's original saw and cutting lathe.

modifications, constant elimination, constant substitution, working in the direction of ever-increasing educational efficiency, are the only means by which a museum can ensure live, active service to its community in the education of both young persons and adults,—the only way in which it can avoid becoming either static or overweighted.

To the author it seems that the Deutsches Museum is in some danger on this score. It is so large that even superficial inspection of its contents requires six or eight extended visits. Furthermore, some of its departmental collections are becoming too highly complex and specialized for the appreciation of the layman. In some groups the amount of material of a closely related character is out of proportion to the ideas represented or at least to the ideas capable of being grasped by the average visitor. It would appear as if the highly specialized staff working with intense enthusiasm over a period of years has approached the danger line in accumulating material. In other words they have reached the point where the significant is in danger of being overwhelmed by quantity and complexity and the psychology of the visitor with his limited powers of observation and absorption lost sight of.

In these respects the policies of the Vienna museum merit close attention. There the greatest care has been taken in selecting only material of the highest significance, in rigidly holding down the collections to the objects that tell an important story, and in eliminating all others.

A museum should be provided with a lecture room seating about 300 equipped with demonstration tables and apparatus for the projection of still and motion pictures. For its educational work a comprehensive supply of industrial films will be needed. It should seek throughout the world for examples of basic primitive industries in order that motion picture records may be

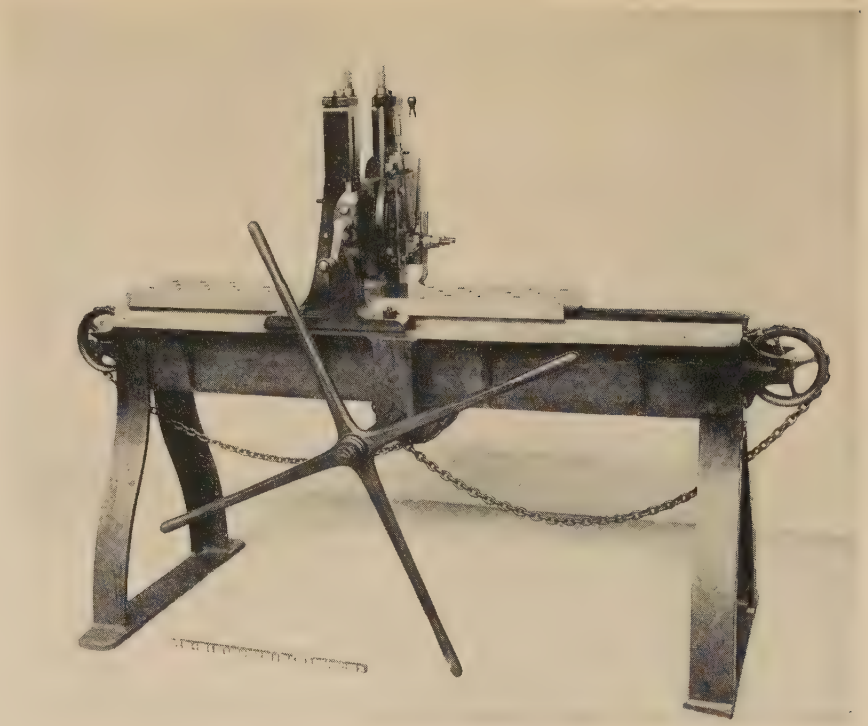
obtained before these craft processes have entirely vanished.

A well developed workshop will be required, the main function of which would be the construction of models for the collections. One of the very practical benefits that might be realized from the establishment of the first industrial museum in America would be the economical production of duplicate models for later museums.

It is difficult to estimate the expense of maintaining in our country a museum of the kind described in any accurate fashion because of the lack of precedents. Some approximate estimates may, however, be made. If we assume a building of the size of the Technical Museum in Vienna, that is, with an exhibition space of 166,600 square feet, and collections and activities similar in extent to that institution, there would be needed for the maintenance of such a museum when fully developed a budget of at least $500,000 a year. Of such an amount $300,000 would probably be required for salaries and wages, and the remaining $200,000 for materials and supplies, fuel, light and power, printing and publications, workshops, and miscellaneous purposes.

It would probably require something like five years after a building and funds became available to develop an industrial museum of the scope above described. During this period of growth an increasing budget, starting perhaps at $100,000 a year and advancing by steps to the above amount by the close of the fifth year, would probably be sufficient to insure normal development. If the museum were recognized as a public institution by the municipality in which it is established and received from the latter assistance toward its maintenance, the burden upon endowment or other sources of income would of course be lessened.

Could such a museum be once established on a basis that would enlist public confidence, it is certain that wide cooperation from manufacturers and corporations would



Science Museum. Planing machine of Roberts.

readily be obtained. In all probability its problem would not be that of obtaining material, but rather that of selecting material most appropriate to its purposes. The attitude of industry and transportation toward the museum idea is already clearly indicated by numerous special collections that have been organized. Notable among these is the Industrial Museum of the American Steel and Wire Company at Worcester, Mass., the museum of the Bethlehem Steel Company and the Bethlehem Ship Building Corporation, and the exhibits of the New York Central Railroad and the Baltimore and Ohio Railroad. These collections indicate an interest that is rapidly growing and suggest in part the extent of cooperation that an American industrial museum could count upon from the industrial interest of the country.

APPENDICES

APPENDIX 1*a*

THE MUSEUM OF OCEANOGRAPHY—BERLIN

(Museum für Meereskunde)

The Museum of Oceanography in Berlin is a remarkably interesting and well developed institution. The museum is a department of the University of Berlin but is intended to serve for the general education of the people as well as for specific instruction. The museum collections aim to stimulate and disseminate "By means of its collections, in the widest circles of our people, an appreciation and understanding of the ocean and its phenomena, the means of investigation, the wealth of its life and its economic value, as well as of the economic and national significance of navigation, shipping, and sea power."

Because of this broad aim, the collections set forth both the scientific aspects of the ocean and practical phases of the trades and industries that center thereon. In the words of the printed guide "it therefore illustrates by means of an oceanological collection the size, the chemical and physical conditions, as well as the movements of the ocean; it shelters in an instrument collection the instruments that serve for marine research and for shipping; it presents in a biological collection the life of the ocean, and shows in a fisheries group how the treasures of the sea are obtained and how particularly the sea animals are rendered serviceable. A historico-economic collection is devoted to shipbuilding, navigation, shipping, the harbor system and the rescue system. To these three divisions there is added, as a component part of the museum, the national navy collection which is devoted to the history and development of the German Navy."

The exhibits are accompanied by detailed labels presenting descriptive matter. In each room there is a tablet giving a brief indication of the contents of the room.

Three rooms contain finely constructed and effectively displayed models of German warships beginning with the wooden vessels that formed the early types of the German navy. These are in many cases about six feet long and a case is devoted to each model. Other rooms contain models of ships of the merchant marine including a

sectional model of the Deutschland about 30 feet long with engines, steering gear, and other apparatus arranged to operate electrically by the attendant. Many of the models are arranged in this manner.

There are many models showing details of ship construction, both wood and iron, and a room devoted to naval artillery, torpedoes and mines. Other rooms contain models of engines, marine boilers, steering gear, windlasses, control devices and signalling apparatus.

The apparatus and methods employed by the life-saving service are extremely well illustrated. The room containing models of fishing and off-shore boats is particularly interesting. Models from 15 to 30 inches long depict the types of boat employed on every section of the European coast. Yachts are also given considerable space. Methods of laying up and repairing of ships on beaches are shown by scenic groups.

Another room is devoted to the fisheries. Well developed case displays show the different methods in which nets and trawls are operated in the North Sea fisheries.

Docks and loading machinery and the function of buoys and lighthouses are represented and deep sea dredging is illustrated. One room is devoted to a collection of nautical instruments.

The scientific side of oceanography is presented in its physical, chemical and biological aspects. Well developed habitat groups show fish and marine plant life. Color transparencies of marine plant and animal life are much used in the windows.

Other rooms contain products of the sea which possess commercial value either as food or through manufacture.

As a whole the art of display has been most carefully considered throughout the museum. The examples selected are always significant and well placed. Much attention has been paid to developing an appropriate atmosphere through large paintings on the walls and by the grouping of material.

Frequent public lectures by specialists have been given in past years at the museum intended to develop a popular understanding of oceanography and to awaken an interest in the national and economic importance of the sea interests of the German people. These lectures have been printed, supplied with illustrations, maps, and sketches and made available at a very low price.

Museum of Oceanography, Berlin. Hall of warship models.

APPENDIX 1*b*

MARINE MUSEUMS

Outside of the maritime collection in the Rijks Museum in Amsterdam and the collections of like character in museums already referred to, there exist in different cities of Europe several distinctive marine museums. Among these there are the Musée de Marine at the Louvre in Paris, two marine museums in Rotterdam, and one in Amsterdam.

National Technical and Nautical Museum—Rotterdam

The marine museums are all of a historical character with the exception of the National Technical and Nautical Museum in Rotterdam (Nationaal Technisch Scheepvaartkundig Museum). This museum, which was founded in 1916 and is maintained by the Dutch shipping interests, serves as a bureau of information upon shipping affairs and also as an educational institution for the instruction of young men in the merchant marine. Its collections are devoted to models, drawings, and specimens illustrating ship construction and operation and marine methods designed principally for the information of those engaged in shipping. Of equal importance for the purposes of the institution is its library and reading room containing works on navigation, ship construction and operation, and maritime periodicals of all countries.

The staff of the museum endeavors to give assistance in regard to all inquiries related to the merchant marine. The museum gives the names of firms or individuals that are in position to supply the necessary information, but does not itself give technical advice. This service covers the fields of ship construction, engine practice, navigation, and meteorology. In the latter field the museum gives both lectures and advice.

In its collections the museum endeavors to show the latest details of ship construction for the information of builders and operators. These collections include many details of marine engine apparatus given by the makers comprising a model of a vertical six cylinder modern marine engine electrically actuated, a model of a Parson's turbine, and other examples of engines and of marine boilers. There are a number of ship models, one showing a cross section and one a longitudinal section about 12 feet long. Instruments for navigation and bridge apparatus are comprehensively illustrated. A wireless room and a chart room are reproduced in full size. Methods for

the handling of cargo, particularly as to the loading of grain and coal, are shown in much detail. The different methods of deep sea fishing are shown in a very effective fashion by models.

The museum provides lectures for workers on the ships, general lectures for the public, and some technical lectures for shipping people.

In 1923 there were about 20,000 visitors to the museum. Including those using the library the number was 31,255. The budget for 1923 was 55,000 gulden. ($22,550.)

Musée de Marine, Louvre

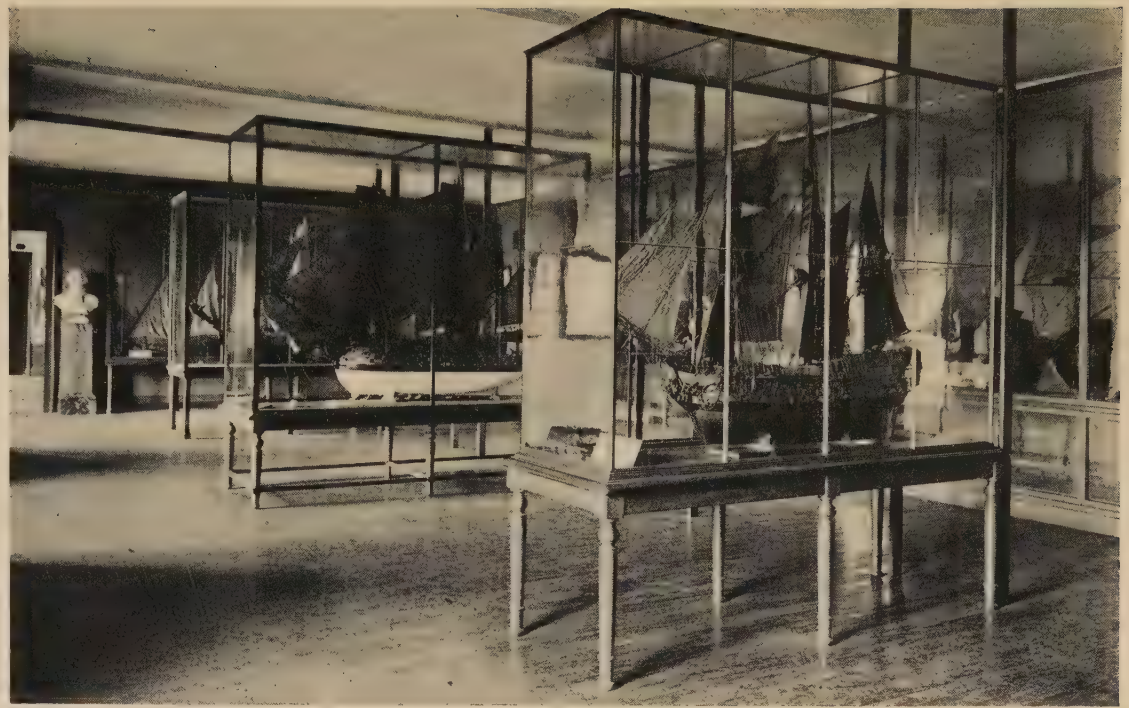
First among the historical museums is the Musée de Marine in the Louvre at Paris which was officially created by a royal ordinance of December 27, 1827. Various efforts to develop naval collections had been made in France in much earlier times. A French naval museum was installed in the Louvre with the approval of the Minister of Marine in 1752, and placed under the authority of the Academy of Sciences. Later on, under the Directory, the authorities determined that the "paintings, drawings, engravings, models, charts, and other objects relating to the navy which are to be found in the national depots and conservatoires, shall be reunited in one place to serve for the advancement of nautical science." This attempt resulted in the development of a naval collection in the grand gallery of the Garde-meuble in 1801. Both of these collections, however, seem to have been dispersed in later years.

For a number of years during the last century the budget of the Minister of Marine included an item providing for the construction of models for the museum in various government naval establishments. Due to this provision, many fine models, executed to a uniform scale of one-fortieth, were constructed in different French naval arsenals between 1830 and 1848 and sent to the museum. A workshop, established in the Louvre itself, produced some beautiful models of the seventeenth and eighteenth centuries.

The collection has been added to by purchases and gifts and today includes many attractive and interesting models of early ships of the French navy. The museum also contains many paintings, drawings and engravings of historic interest, prominent among which are the series illustrating the Ports of France by Joseph Vernet.

The main divisions of the collections are as follows: harbors and arsenals, naval construction, naval armament, navigation, ships of war, merchant marine, objects of art relating to naval history including paintings, busts, and ornaments.

The collection, as a whole, is not arranged in a particularly attrac-



Musée de Marine. Room containing models of early French ships of war.

tive manner or in a way calculated to develop a pronounced educational effect. In a number of cases the material exposed in wall cases is much too crowded and the lower portions are almost impossible to inspect. Some of the rooms have very poor light. There is no exposition of the industries or activities of the sea, no material relating to sea trade, and very few exhibits showing ship construction. The value of the museum rests almost wholly upon the historic and æsthetic appeal of many fine models of French ships of war and off-shore boats of various countries which, unfortunately, are not always displayed to the best advantage as regards light and opportunities for observation.

Marine Museum, Rotterdam

Another historical marine collection is located in the Ethnographical and Marine Museum in Rotterdam (Museum voor Land-en Volkenkunde en Maritiem). This museum is, to a large extent, an ethnographical museum with collections gathered principally from the Dutch colonies. It includes, however, a marine section which contains beautiful models of early Dutch sailing craft and fishing vessels. There are also a number of models of Oriental sailing craft, models of modern Dutch steam vessels, and models of marine engines.

Netherlands Historical Nautical Museum, Amsterdam

The Netherlands Historical Nautical Museum (Nederlandisch Historisch Sheepvaart Museum) in Amsterdam was founded in 1916 and is supported by private funds largely from shipping companies and individuals. The direct incentive that led to the organization of the museum was, as in the case of the Nautical and Technical Museum at Rotterdam, the Netherlands Nautical Exposition held in the year 1913 on the occasion of the centenary of Dutch independence. It was found at this time that much of the material in the historical section of the exposition was liable to go to England or America and an association was formed to keep this material in Holland.

The museum is purely historical but it is thoroughly educative in the sense that it not only contains a collection of models and documents of the highest value, but displays them in a manner that allows their significance to be readily comprehended and their æsthetic quality thoroughly enjoyed.

The building, which was finished in 1922, is not large and consists of only two floors, each with a central hall and wide alcoves. There is abundance of light at all points and the arrangement is such as

to give an impression of spaciousness and of freedom from crowding. In the halls and alcoves are models of historic Dutch ships ranging from picturesque examples of the fifteenth century to those of today. Each model stands alone in a glass case.

At the sides of the alcoves are generally arranged counter cases containing elaborately printed old Dutch works on voyages, navigation, and astronomy, and on the walls above are charming specimens of old charts, engravings of Dutch admirals and old Dutch marine paintings sometimes by great masters like Van der Velde the elder.

The display as a whole is of the highest order, both from the technical and artistic standpoint. The discrimination and taste that have presided over the arrangements have resulted in one of the most attractive small museums in Europe, one that in point of æsthetic appeal vies with that of any art museum.

A library consisting of old and new works relating to the history of the sea is maintained by the museum.

The museum publishes each year a volume of fine typographic appearance on some topic concerning the history of Dutch naval affairs.

APPENDIX 1*c*

TRAFFIC MUSEUMS

The Traffic Museum at Berlin is one of three traffic museums developed in Germany by the Imperial Railway Directory. These museums were originally intended for the instruction of railway employees in regard to methods and technique but of late years they have been conducted as public museums with the education of the public concerning railways as an important if not their chief aim.

Museum at Berlin

The museum in Berlin (Verkehrs-und Baumuseum), which was opened on December 14, 1906, is housed in the former Berlin-Hamburg passenger station to which in 1911 and 1916 were added two side wings. The large central hall of the old passenger station is devoted to examples of full-sized locomotives and cars of various types as well as a large number of models in cases. In this hall are also a number of full-sized car trucks showing air-brake systems in full detail.

Behind the great hall and connected with it is a switch house or

Marine Museum, Amsterdam. View of first floor.

tower connected with a railway yard located in a court in which appurtenances, switches and signal installations are operated from the tower.

Other rooms contain models of various types of bridges and turn tables, models of switches and signals, coal loading machinery, train dispatching and telegraph and telephone systems, tools used in railway construction, printed matter and charts relating to railways.

One of the long side wings is devoted to the Haarmann rail museum. This collection presents in an exhaustive way the historic development of road bed and rails. Rails, fish plates, saddles, sleepers, and ballast are all shown by full-sized specimens in two rooms each approximating 200 feet in length. In the corresponding wing on the opposite side, models of canals, locks, dams, docks, bridges and relief maps of harbors illustrate the field of water transportation.

The models which figure in the collections in such large numbers were in part made in government or private shops from government funds and in part presented by private firms and represent constructions in actual or in small scale. Some of the models of locomotives, brakes, and safety installations can be actuated by means of compressed air or electricity.

The museum contains a very large collection of material much of which is very similar in character. The extent and repetitive nature of the collection are such as to induce fatigue in the lay visitor rather than to favor the assimilation of ideas. No attempt has been made to limit the displays to type and significant material but rather every effort has been put forth to make the collections comprehensive. The museum is in consequence not an effective institution for public education. For this purpose much of the full size material could be better shown by photographs, drawings or models and the entire display greatly condensed. The number of visitors at present is stated to be 125,000 a year.

Museum at Dresden

The museum at Dresden has been only recently established. It represents a very interesting museum on a small scale developed very intelligently through effective use of drawings, charts, and models. The collections are at present located in several rooms in the Neustadt Bahnhof that are not very suitable for display purposes, but which have been made use of to the best advantage.

In the entrance room are historic documents and drawings relating to the first German railway opened in 1837 which ran between Dresden and Leipzig.

The first exhibition hall contains excellent models of bridges with accompanying detail drawings. Each model is provided with a case and has been made in such a manner as to show the construction.

The large room of the museum is devoted to various models, drawings, photographs, and constructive details. The development of rails and a road bed is shown by short sections and by wash drawings. A case about 4 feet long contains 24 nickel plated sections of rails and fish plates. This and other instances among the displays are models of condensation. A working section of a locomotive valve and a link motion is exhibited together with drawings of a locomotive of which it forms a part. Specimens of locomotive parts broken in accidents resulting from lack of care on the part of operatives are exhibited in such manner as to bring out the cause of the accident.

A small study room has been provided in which books and reports can be consulted.

The museum is maintained by the Railroad Directory of the State of Saxony.

Museum at Nuremberg

The Bavarian Traffic Museum was founded in Munich in 1885 but in 1889 was transferred to Nuremberg. At first, as in the case of the Berlin museum, it was intended only for the instruction of railroad employees, but now aims largely at the education of the public. A new building, which was begun in 1914 and finished in 1925, was planned largely with this end in view and now presents a fine example of a specialized museum building. The outer walls are built of brick with sand stone facing. The floors are constructed of reinforced concrete. The museum building, which is connected by a bridge with the administration building of the Nuremberg Railroad Directory, consists of four wings about a central court that is developed in attractive architectural fashion. The walls of the different rooms are treated in various colors, both for the sake of variety and for easy identification.

The displays of the museum are marked by an entire absence of full-sized locomotives and coaches. Reliance has been laid solely upon finely constructed models together with drawings, diagrams, photographs and constructive details. The models of locomotives and coaches are constructed to one-tenth scale and are arranged in units of a locomotive and two coaches, each of which is displayed in a glass case about 12 feet long, 20 inches wide, and 24 inches high. One large room contains 32 of these cases. Other rooms contain displays showing the construction of bridges and the permanent

Agricultural Museum, Budapest.

way, railroad buildings, electric railways, brakes and other examples of railway mechanism, and scenic panorama illustrating river transportation and railroad building.

There is a complete model of a block signal system constructed at a scale of one to twenty. This and other models are actuated only by keepers or guardians.

The museum devotes considerable space to the postal service. Models of post wagons, both of old and new types, are exhibited. Railway and postal telegraph instruments are shown and diagrams bring out the operation of both telegraph and telephone apparatus.

A fire-proof room or vault is devoted to a very extensive and valuable collection of stamps of all countries.

A fine room about 30 feet by 50 feet is provided in the museum building for staff conferences of railway officials and another of the same size for festivals.

There is a well arranged lecture room provided with motion picture apparatus in which it is proposed to give public lectures with the hope that some revenue may be obtained from this source to assist in the upkeep of the museum.

In the basement are rooms for holding the archives of the railway administration and workshops for model making.

A refreshment room of attractive character has been incorporated in the building. This room allows for expansion during the summer into a delightful outside loggia.

APPENDIX 1*d*

AGRICULTURAL MUSEUM—BUDAPEST

The Agricultural Museum in Budapest, which was described in an admirable paper on agricultural museums by F. Lamson-Scribner presented at the meeting of the American Association of Museums May 26, 1921, was founded as a state museum in 1896. The museum was organized to conserve the extensive agricultural collections brought together at the time of the Hungarian Millennial Exposition. The three very picturesque buildings that were erected for the agricultural collections at that time were built in three different styles typical of Hungarian architecture—Romanesque, Gothic, and Renaissance. These buildings were first erected as temporary structures for the purpose of the exposition, but were after-

wards rebuilt in permanent and substantial fashion at a cost of 2,400,000 kronen (about $480,000) in 1903, and in 1907 were opened to the public.

The aim of the museum is to illustrate the development of Hungarian agriculture on the one hand and to serve as a bureau of information upon agricultural matters on the other. The scope of the collections is extremely comprehensive, embracing the entire field of agriculture, horticulture, forestry, animal husbandry, fish culture, game, and agricultural industries.

In the agricultural section the culture of cereals, vegetables, and tobacco is illustrated by specimens showing the result of proper and improper methods. One entire room is devoted to wheat culture. Chemical analyses of the various qualities of wheat collected from the 53 counties of Hungary are displayed together with samples of the upper and lower strata of the soil in which the respective qualities of wheat are grown. In this room is also a collection of prehistoric seeds dating from the stone and bronze ages.

The work of the agricultural schools is fully illustrated by models, photographs, and records. In this section is an extensive collection of models of Hungarian farm buildings which illustrate the older types as well as the new.

The relation of insect life to agriculture receives detailed exposition in which the functions of harmful and helpful insects are clearly brought out. Methods of soil culture are illustrated and the history of the plow is set forth at considerable length by means of small models illustrating types used in different countries as well as of full size specimens of modern plows and harvesting machinery. Horticulture receives the same thorough attention.

Methods of forestry conservation are illustrated by photographs and models and by comprehensive collections of Hungarian woods displayed in the log and in sections. The work of the forestry schools is also explained.

The dependence of Hungary upon the regulation of her river systems is brought out by maps both in the flat and in relief, and methods of conservation and regulation of river supply are illustrated.

The department of animal husbandry comprehends horses, cattle, sheep, poultry, and rabbits. The results of breeding are set forth and economic considerations regarding marketing are dealt with.

A distinctive feature of the museum is two halls, one of which is devoted to portrait models about 20 inches in length of some of the most famous stallions and brood mares of Hungary, and the other to similar portrait models of noted specimens of horned cattle illustrating standard breeds. In this connection are models and photo-

Agricultural Museum, Budapest. Hall containing models of farm buildings.

graphs showing the active equipment of the state breeding establishments.

Bee culture is illustrated at length. Dairy farming, the milling industries, the spirit industries, brewing, beet sugar production, the vegetable oil industries, the starch industry, vinegar production, and the flax and hemp industries are illustrated by models, photographs, specimens of raw and finished materials, and by statistics.

Hungarian river and lake fish are illustrated by photographs and habitat groups and methods of fish culture are set forth. Methods of fishing by weirs and nets are illustrated.

Several large rooms are devoted to the wild game of Hungary. The finely mounted specimens are shown both in their winter and in their summer coats. A feature of this exhibit is the inclusion in each case of the footprints of the animal. Colored game maps show the distribution of wild animals.

As a whole the museum displays are of a very high order. Every effort has been made to make the collections thoroughly informative and at the same time attractive. Diagrams, relief maps, models and photographs have been employed most intelligently and effectively throughout the collections. Photographic transparencies in the windows have been largely used.

The museum possesses a fine public library relating to agriculture and allied fields and has an excellent lecture room. Courses of public lectures upon agricultural topics are held and scientific publications are issued by the museum. Active contacts are maintained with the agrarian life of Hungary and the museum authorities are constantly supplying data and advice on agricultural matters. The museum shows clearly the influence of an intelligent and active administration working for the benefit of the agricultural interests of Hungary as well as toward the development of a museum for the education of the public.

APPENDIX 2

DEUTSCHES MUSEUM—MUNICH

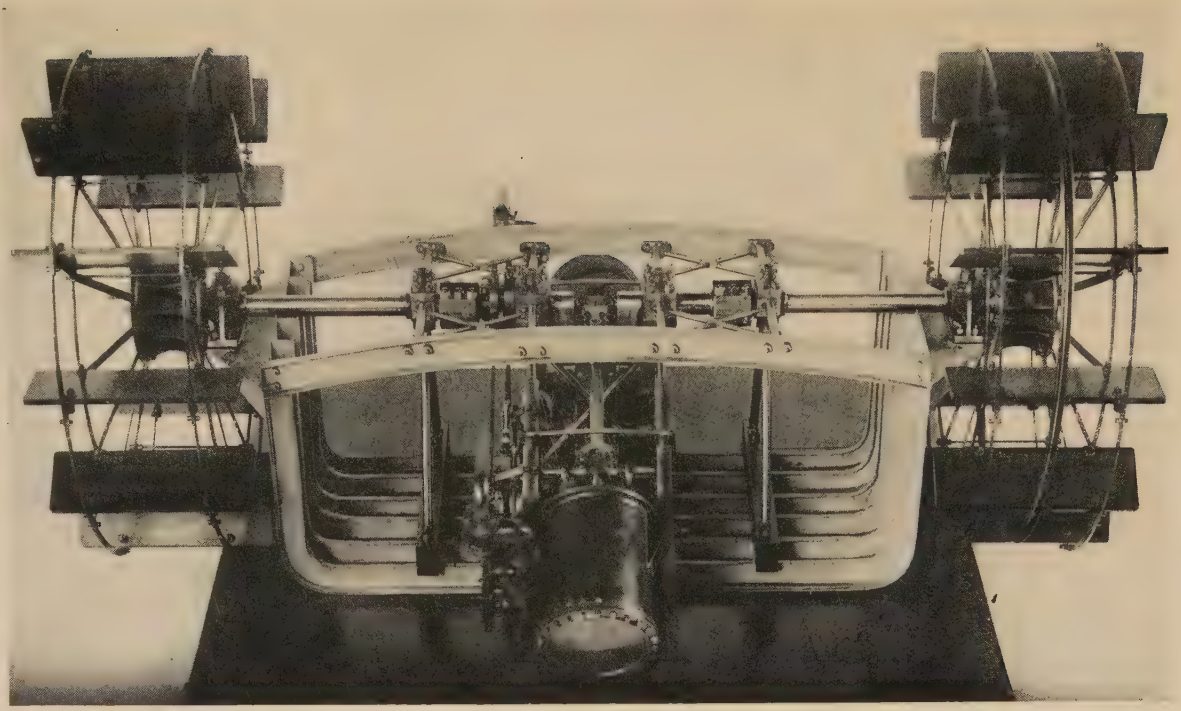
Transcript from the catalog of the displays in the old building

Geology

A. Development of views concerning volcanic phenomena. (Pictures, models, and diagrams.)
B. Apparatus for determination of earthquakes.
C. Causes of the formation of mountains. (Models and pictures.)
D. Action of wind and water upon the surface of the earth. (Diagrams and pictures.)
E. Examples of typical petrifactions. (Specimens and casts.)
F. Development of views regarding the formation of the most important rocks, coal seams, etc. (Pictures and specimens.)
G. Picture of a landscape from the Devonian age.
H. Picture of a landscape from the Carboniferous age.
I. Picture of the region of Steinheim in the Tertiary period.
K. Reconstruction of the region around Munich in the Glacial Epoch. (Picture and map.)
L. Glacial rubble-stones from the Glacial Epoch. (Specimens, maps, pictures.)
M. Development of geological maps. (Maps and globe.)
N. Development of geological reliefs. (Topographic reliefs.)
O. Development of methods for the investigation of rocks. (Apparatus for analyzing and determining of rocks and minerals; historically important instruments in this field; polariscope and microscope.)

Mining

A. Development of deep drilling tools and machines. (Pictures and models.)
B. Shaft drilling plant according to Kind-Chaudron. (Operating model.)
C. Lined shaft with Thompson water suction system. (Model.)
D. Freezing shaft plant. (Model.)



Conservatoire des Arts et Métiers. Model of engine and paddle wheels of river steamboat.

E. Pictures regarding the development of the salt mining industry. (Diagrammatic drawing, pictures, and plan.)
F. Methods for the extraction of salt from brine. (Models, pictures and samples of the most important salts.)
G. Pictures relating to the development of ore mining.
H. Ore mine of the period of about 1830. (Scale model.)
I. Development of the dressing of coarse- and fine-grained ore. (Pictures and models.)
K. Development of electro-magnetic dressing of ore. (Original machines.)
L. Picture of a lignite mining plant.
M. Pictures regarding the development of hard coal mining. (Pictures and plants.)
N. Self-acting inclined plane installation of the coal mine at Hansau. (Operating model.)
O. Typical plants for the dressing of coal. (Model.)
P. Plants for making briquettes. (Operating model.)
Q. Earlier conveyor installations for shafts. (Pictures and models.)
R. Electric conveyor plant. (Operating model.)
S. Methods for the removal of noxious gases. (Pictures and models.)
T. Development of water control plants. (Models.)

Mining Plants

I. Shaft Installations

A. The various forms of lining of shafts and drifts. (Models.)
B. Early shaft with wooden lining, elevator basket, and cars. (Model.)
C. Shaft with masonry lining, iron elevator basket with earlier safety catch. (Model.)
D. Shaft with iron lining, elevator basket with more recent safety catch. (Model.)
E. Pictures relating to the development of shaft conveyance.
F. Model of a miner's cage of the eighteenth century.
G. Historic water control arrangements. (Model.)

II. Safety and Rescue Devices

H. Miners' lamps and rescue devices. (Specimens.)

III. Tools and Drills

I. Earlier and more recent mining implements. (Specimens.)

K. Obtaining of coal by means of long-way work. Ladders for communication between levels. (Representations.)
L. Hand drilling. (Representations.)
M. Machine drilling with operation by hand. (Machines.)
N. Hydraulic and pneumatic drilling and long-drilling machines. (Specimens.)
O. Compressor plant. (Machine.)
P. First electric drills of Siemens, 1879.
Q. Earlier and more recent mine ventilators for removal of noxious gases from isolated places. (Machines; old specimens.)
R. Means for blasting. (Cartridges, fuses, etc.)

IV. Hoisting Devices

S. Old self-acting inclined plane installation with cable drum.
T. Conveyor reel for operation by steam and water. (Specimens.)
U. Conveyor support for self-acting inclined plane. (Specimen and two cars.)

V. Conveyance in Drifts

V. Wooden car of the 16th century.
V. Guide-rail barrow of the 17th century.
V. Shaft elevator basket with iron car arranged for tipping. (Specimen.)
W. Picture of a stable arrangement for horses.
X. Operating model of a chain conveyor system.
Y. Earliest electric mine locomotive of Siemens.
Y. Gasoline mine locomotive.
Y. Pictures relating to the development of drift conveyors.
Z. Development of the lining of drifts with stone, wood, and iron. (Representations.)

Metallurgy and Metal Wcrking

Production of Pig Iron

A. Diagrammatic representation of the production of iron and steel.
B. Ores and substances that are added for various kinds of iron.

Science Museum. Railway carriage of 1825.

C. Arrangements for the preparation of charcoal and coke. (Models.)
D. Earlier and more recent blowers. (Models and drawings.)
E. Pictures relating to the development of air heaters.
F. Pictures relating to the development of blast furnaces. (Pictures and drawings.)
G. Details of blast furnaces.
H. Iron-sheathed blast furnace in cross-section. (Model.)
I. Blast furnace plant at Baruth from the eighteenth century. (Model.)
K. Earliest blast furnace with air heater.
L. Blast furnace plant from the period of about 1875. (Model made to scale.)
M. Blast furnace puddling tools. (Specimens.)
N. Earliest pig iron mixer. (Operating model.)

PRODUCTION OF WROUGHT IRON, SOFT STEEL, AND REFINED STEEL

I. *Production of wrought iron.*

A. Old bloomery fire, with an original iron bloom. Also original of a refinery hearth of the middle of the nineteenth century.
B. Earlier and more recent puddling furnaces. (Sectional models and specimens of iron and steel.)

II. *Production of soft steel.*

C. Cross-section of a Bessemer converter of 1867. Beside it is an operating sectional model of the first Bessemer plant known in Germany (1863).
D. Earliest Siemens-Martin plant in Germany (1868). (Model.)

III. *Production of refined steel.*

E. Cementation furnaces. (Sectional model and photographs and specimens.)
F. Development of crucible steel furnaces. (Sectional model of the year 1811. Also a model of a modern crucible steel furnace. Specimens of crucibles and picture of casting of steel. Various specimens of steel fractures. First cast steel bell.)
G. Electric steel furnaces. (Models. Representation of methods of testing iron and steel.)

WORKING OF IRON

I. *Rolling.*

A. Diagram of the rolling processes. An old rolling mill. (Diagrammatic drawing and model.)
B. Rail rolling mill. (Operating model of the Krupp type of about 1880; also specimens and pictures.)
C. Rolling of a piece of strip iron, a rail, and a chain. (Specimens showing stages of development.)
D. Blooming mill. (Operating model.)
E. Three-high mill. (Original of the Erdmann system.)
F. Stages of development of rolled sheet metal. (Specimens of materials.)
G. Development of armor plate. (Specimens of Krupp armor plate of wrought iron, composite plate, unhardened nickel steel, hardened nickel steel; picture. Specimens of armor plate that had been subjected to fire.)
H. Tube rolling mill. (Model and samples.)

II. *Forging.*

I. Old forge with old implements and forged products. (Forge shop reconstructed by Prof. Klieber.)
K. Development of water and steam hammers. (Series of models and drawings.)
L. Krupp forging hall with model of the "Fritz" hammer of 50,000 kilograms pressure. (Model to scale.)
M. Model of a forging press with a pressure of 3,000,000 kilograms. (Model and specimen.)

III. *Welding.*

N. Welding processes. (Pictures, specimens, and diagrams.)

IV. *Casting.*

O. Molding machines. (Models and originals.)
P. Development of cupola furnaces and molding machines. (Models.)
Q. Special casting processes for special requirements. (Models and specimens.)

Science Museum. Model of H.M.S. Prince of 1670.

Hydraulic Motors

I. Water Wheels

A. Overshot, middle shot, and undershot water wheels. (Operating models, original wheel, drawings.)

II. Water Pressure Engines

B. Water pressure engine of Reichenbach. (Original and models.)
C. Typical water motors. (Originals and drawings.)

III. Turbines

D. Old Rumanian tangential water wheel. (Specimen, pictures.)
E. First turbine in Germany by Fourneyron. (Original.)
F. Model of a Nagel turbine. (Model.)
G. Sectional model of a Schwamkrug turbine by Ganz.
H. Zuppinger tangential turbine by Escher-Wyss. (Original.)
I. Original Pelton wheel. (Original and operating model.)
K. First Francis turbine with Fink rotary-blade regulation, by Voith.
L. Original of the first Henschel turbine.
M. Adjustable Knop turbine of Briegleb & Hansen. (Original and pictures.)
N. "Ontario" turbine plant. (Model and sectional drawings.)

Oldest Steam Engines

A. Pictures relating to the development of the steam engine.
B. Oldest steam engine existing in Germany. (1813.) For comparison, high-speed Westinghouse steam engine.
C. Model of the oldest steam engine plant. (Model, original beam.)
D. Model of a Watt engine with planetary wheel.
E. Beam engine with frame. (Original and operating model.)
F. Half-beam engine. (Original and operating model.)
G. Alban steam engine. (Original and operating sectional model.)

Steam Engines and Steam Boilers

I. Steam Engines

A. Historic types of vertical steam engines. (Originals, and cast models of steam engine frames.)
B. Historic types of horizontal steam engines. (Original engine and parts.)
C. Development of steam engine valve gears. (Original models, section of a cylinder.)
D. Side-beam marine engine of Coquerill. (Original.)
E. First torpedo-boat engine of Schichau.
F. Historically important multiple-expansion engines. (Drawings and models.)
G. Section of a cylinder of a more recent Sulzer valve engine.

II. Steam Turbines

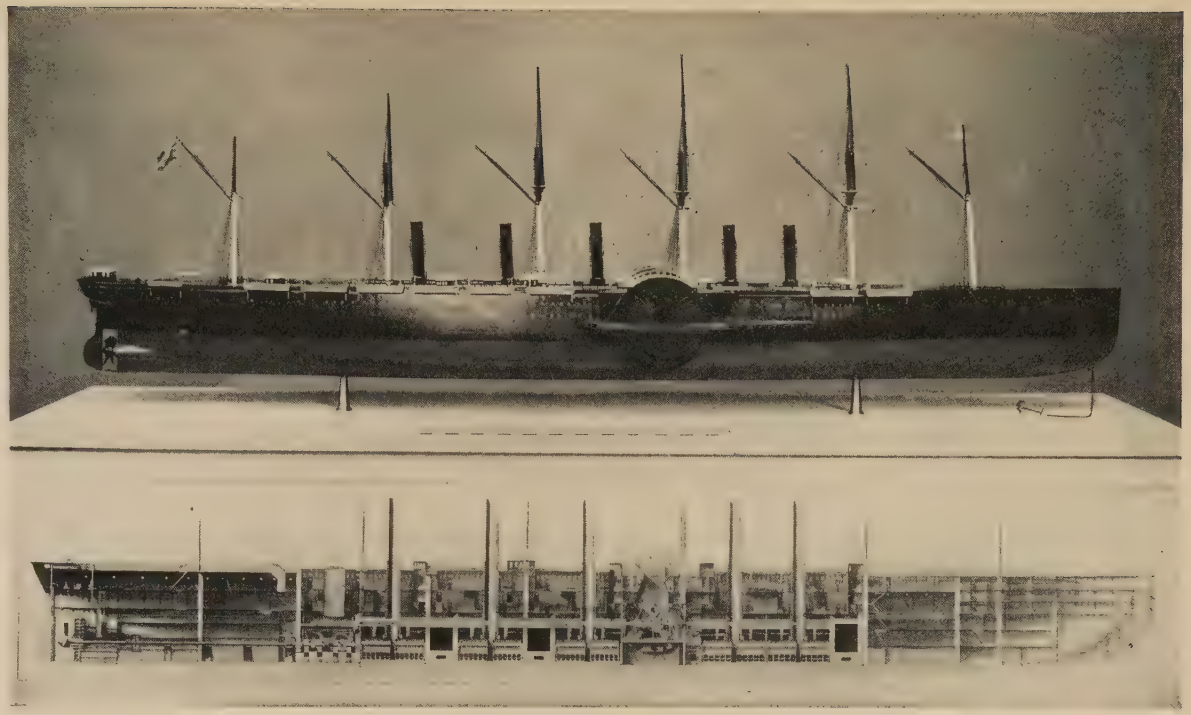
H. Steam turbines of Laval and Parsons. (Original, model, drawings.)

III. Steam Boilers

I. Old copper boiler of Watt.
K. Development of boilers with large water space. (Models, sectional model, original of a large marine boiler bottom.)
L. Original tubular boiler of Alban.
M. Original of the first Steinmüller boiler.
N. More recent tubular boilers. (Sectional models, pictures.)
O. Representation of steam boiler explosions. (Pictures, components of exploding boilers.)
P. Preheating of the boiler feed water. (Model.)
Q. Models of water re-cooling plants. Also model of the first water purifier built in Germany.
R. Older and more recent fittings. (Originals.)

IV. Steam Automobile Engines

S. First German locomobile of Wolf.
T. Model of a modern superheated steam locomobile of Wolf. (Model, drawings, photographs.)
U. Direct-current superheated-steam locomobile of the Maschinenfabrik Badenia.



Science Museum. Model and sectional drawing of the Great Eastern.

V. Steam Plants

V. Locomobile central plant of Lanz. (Reduced-scale model.) Comparison of various steam engines and steam boilers for an electric power station. (Models.)

Land Transportation

Carrying of Loads and Persons, Sleds and Wagons, Bicycles

A. Carrying of loads and persons by human beings. (Objects and pictures.)
B. Carrying of loads and persons by animals. (Model and pictures.)
C. Development of drags and sleds. (Originals and pictures.)
D. Development of wagons. (Models and pictures.)
E. Traveling coach of the Biedermeier period. (Original.)
F. Mechanical wagons. (Pictures, typical mechanical tricycles.)
G. Development of bicycles. (Originals.)

Automobiles and Railroads

I. *Automobiles.*

A. Development of automobiles and motorcycles. (Originals, models, pictures.)

II. *Locomotives.*

B. Development of locomotives. (Models and pictures.)
C. Reproduction of the first locomotive, "Puffing Billy."
D. First locomotive of Krauss.
E. Express locomotive of the year 1874. (Sectional locomotive; can be operated by means of an electric motor.)

III. *Mountain Railways.*

F. Rigi railway, the first cog railway in Europe. (Models of locomotives and roadbed.)
G. Pilatus railway, cog railway with greatest inclination. (Model of motor car and of a viaduct.)
H. Railway from Blankenburg to Tanne, first combined cog and adhesion railway of Abt. (Models of locomotive truck and roadbed.)
I. Development of cable roads. (Models, drawings, and pictures.)

IV. *Railway Cars.*

K. Development of railway cars. (Originals and models.)
L. Statistical tables relating to the development of railways. (Tables on the walls.)
M. Model of a typical ship-canal lift. (Operating model.)

V. *Roadbed.*

A. Originals of historically important railway tracks.
B. Development of roadbeds and tracks from the seventeenth century to modern times. (Sections of roadbed, etc.)
C. Grooved tracks. (Short sections.)
D. Roadbeds of cog railways. (Sections.)
E. Safety devices for the open stretch. (Original devices.)
F. Safety devices at the railway station. (Switches, signals, etc.)

ELECTRIC RAILWAYS

A. First electric locomotive of Werner Siemens. (Original.)
B. Models of historically important electric cars and locomotives.
C. Electric street car with trucks. (Sectional model.)
D. Car of the speed trials from Berlin to Zossen. (Sectional model.)
E. Electric street railway car. (Machinery exposed.)
F. Suspended railway from Barmen to Elberfeld. (Model; also pictures of elevated and subway lines; statistics.)
G. Jungfräu railway, the highest mountain railway in Europe. (Model and painting.)

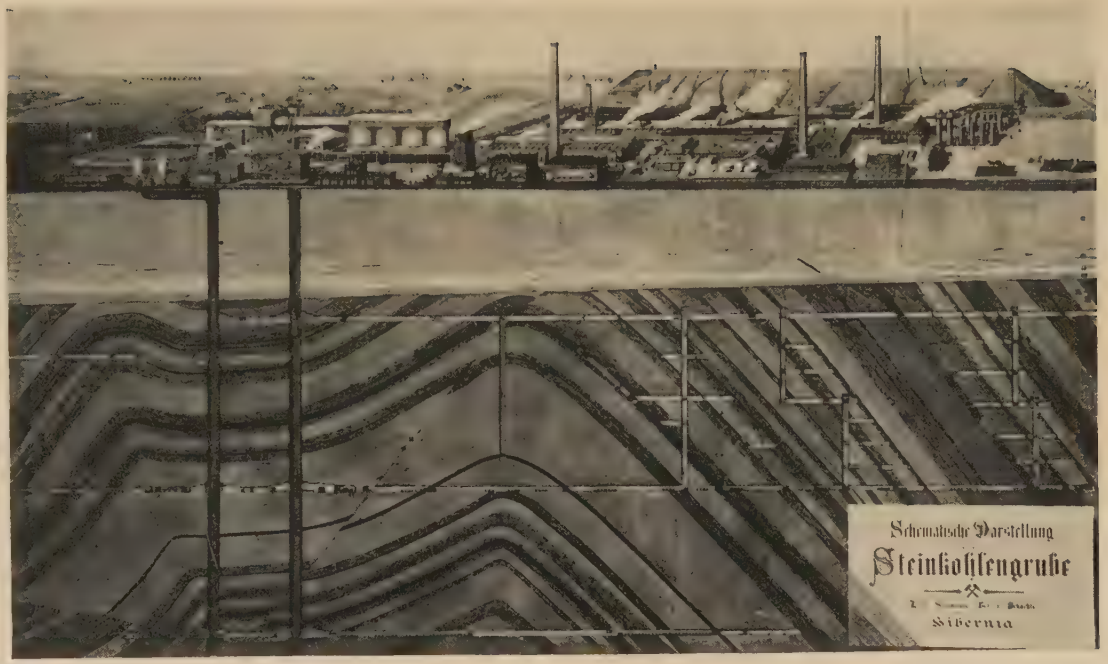
HOT AIR ENGINES, GAS ENGINES, ENGINES FOR LIQUID FUELS AND WIND ENGINES

I. HOT AIR ENGINES

A. Hot air engine of Ericsson. (Original.)
B. Hot air engine of Lehmann. (Original.)

II. GAS ENGINES

C. Gas engine of Lenoir.
D. Gas engine of Otto and Langen.
E. Atmospheric gas engine of Bischop.



Deutsches Museum. Schematic representation of coal mine and plant.

F. Gas engine of Otto; four-cycle. (Reproduction.)
G. Gas engine of Raichmann; four-cycle.
H. Suction gas engine plant of Deutz. (Sectional model and diagrammatic drawing.)
I. First blast-furnace gas engine of Öchelhäuser. (Operating model, partly sectional.)
K. Blast-furnace of Deutz. (Model.)
L. Two-cycle engines. (Original, and diagrammatic sectional model.)

III. Engines for Liquid Fuels

M. Historically important petroleum engines. (Originals.)
N. Gasoline engine of Banki. (Original, partly sectional.)
O. First Diesel engine. (Original, diagrams, pictures.)

IV. Wind Engines

A. Presentation of the history of wind engines. (Pictures and models.)
B. Historic windmill of Sans Souci. (Model.)
C. Typical German windmill. (Model.)
D. Operating models of more recent wind engines with regulating devices. (Also pictures.)
E. Details of old windmills. (Originals and model.)

Astronomy

A. Celestial globes and star maps. (Originals.)
B. Large planetarium from the beginning of the nineteenth century. Two other planetariums, which are movable, etc.
C. Astronomical "world and art clock."
D. Development of the calendar and of the division of time. (Plaster cast, original calendars, tables.)
E. Development of sun dials. (Models and original.)
F. Astronomical pendulum clocks. (Originals.)
G. Astronomical clock by S. Riefler.
H. Armillary spheres and astrolabes. (Pictures and originals.)
I. Development of instruments for the determination of the position of the heavenly bodies in the celestial sphere. (Originals, models, pictures.)
K. Older telescopes for observation of the heavenly bodies. (Originals, reproduction, drawings, and sectional models.)
L. Parallactically mounted telescopes. (Original and models.)
M. Refractor of G. and S. Merz.

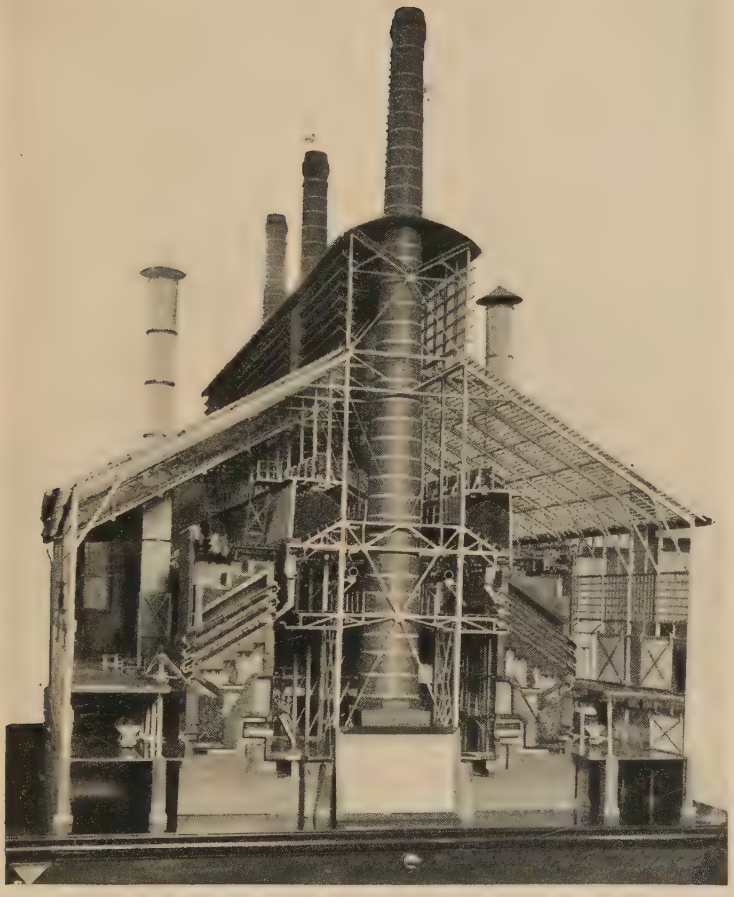
N. Model of a cupola.
O. Fraunhofer's heliometer. (Original and drawing.)
P. Constitution of the sun. (Drawings and photographs.)
Q. Constitution of the moon. (Drawings and photographs.)
R. Constitution of the planets. (Drawings and photographs.)
S. Constitution of comets. (Drawings and a meteorograph.)
T. The world of the fixed stars. (Tables and photographs.)
U. Large tellurium for exemplification of the movement of the earth and the moon.
V. Original instruments of Tycho Brahe.

Geodesy

A. Measures of length. (Survey of units of length, collection of standard measures, copy of the meter prototype.)
B. Measures of capacity. (Survey, and collection of originals.)
C. Telescopic graphometers and apomecometers. (Originals.)
D. Experimental arrangement for apomecometers.
E. Gradual improvement of goniometers. (Collection of instruments.)
F. Progressive improvement of the theodolite. (Originals.)
G. Experimental arrangement for goniometry.
H. Optical squares. (Instruments and explanations.)
I. Development of leveling instruments. (Originals, reproductions, drawings; also altitude barometers.)
K. Altitude charts. (Maps, comparative data, plans in relief.)
L. Base instruments. (Instruments, pictorial representation of a measurement.)
M. Maps. (Comparison of maps; methods for the preparation of cadaster charts.)
N. Linear dividing machine of Repsold.
O. Circular dividing machine of Reichenbach.
P. Circular dividing machine of Oertling.

Mathematics, Cinematics, Balances

I. Mathematics
   A. The development of practical calculation and calculating machines. (Machines, logarithmic calculating devices, tables.)
   B. Exemplification of the most important geometric forms. (Models, tables, demonstration arrangements.)
   C. The development of perspective and its application. (Drawings and models.)
   D. Development of the planimeter. (Originals.)



Deutsches Museum. Model of gas producing plant at Nuremberg.

II. Cinematics

E. Cinematic demonstrations. (Models and tables.)
Cinematics in the animal kingdom. (Preparations and models.)

III. Balances

F. Collection of units of weight and of sets of weights. (Originals and reproductions.)
G. Large two-armed balance of the year 1800. (Also a lever balance.)
H. Ordinary scales. (Originals, models, drawings, reconstructions.)
I. Bridge scales and spring scales. (Originals and models.)
J. Precision balances. (Originals.)
K. Development of densimeters for liquids. (Hydrometers. Instruments.)
L. Ascent to the astronomical observatory. (Instruments, transparent glass star chart.)

Mechanics

I. Equilibrium of Solid Bodies

A. The lever principle and its application. (Models.)
B. Recognition of the principle of the inclined plane and its application. (Models and apparatus.)
C. The principle of the parallelogram of forces and its application. (Demonstrations.)

II. Movement of Solid Bodies

D. Galileo's investigations of falling motion. (Apparatus, reconstruction of apparatus, and machines.)
E. Development of the laws of the pendulum. (Demonstration of the Foucault experiment; instrument.)
F. Reproduction of the centrifugal machine of 'sGravesande.
G. Experiments with centrifugal machines.
H. The law of the attraction of masses and the three laws of motion of Newton. (Explanation, drawings, instrument.)
I. Turn-stool for demonstration of reaction movements.
K. Experiments with tops.

L. Marine gyroscope and gyroscopic compass. (Operating models.)
M. Demonstration of ship vibrations. (Model.)
N. Development of the laws of the impact of elastic bodies. (Reproductions of experiments, models.)

III. Mechanics of Gases

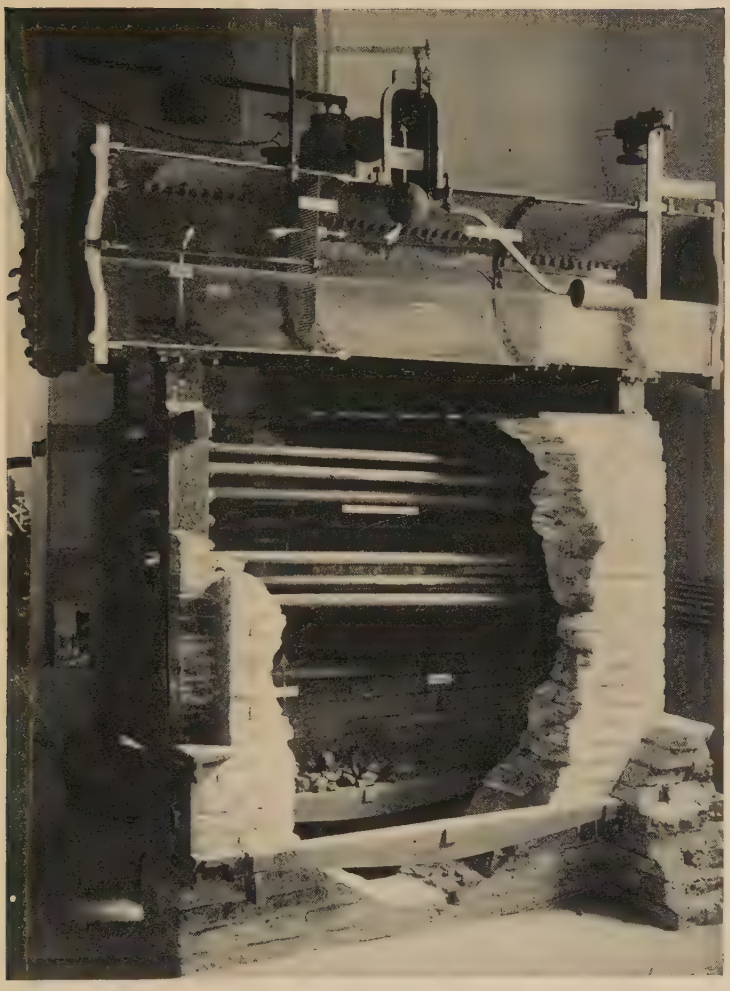
O. Development of the barometer since the time of Torricelli. (Torricelli experiment, reproductions, original instruments.)
P. Original air pump of Otto von Guericke. (Also pictures and explanations.)
Q. Development of piston air pumps. (Original pumps.)
R. Development of mercury air pumps since 1858. (Originals.)
S. Demonstration in a vacuum.
T. The fundamental laws of the mechanics of gases and their application. (Reproductions, drawings, experiments.)

IV. Mechanics of Liquid Bodies

U. The law of hydrostatic pressure and its application. (Demonstrations, reproduction of apparatus.)
V. Hydraulic presses. (Model and picture.)
W. Presentation of the principle of Archimedes.
X. Development of hydrodynamics and application thereof. (Demonstrations and water wheel.)

Optics of Former Times

A. Flat mirrors and their employment. (Drawing, collection of mirrors, model.)
B. The laws of curved mirrors. (Collection of mirrors, experimental arrangements, diagrammatic drawings.)
C. Rectilinear transmission of light. (Model, demonstration, diagrammatic pin-hold camera.)
D. Projection instruments. (Instruments and pictures.)
E. Development of the law of refraction. (Instruments and demonstrations.)
F. The laws of lenses. (Figures to be observed through various lenses; demonstrations and diagrammatic explanations.)
G. Progressive improvement of the microscope. (Original microscopes.)



Deutsches Museum. Fire tube boiler of Alban, 1859.

H. Perfection of the microscope since the invention of the achromatic objective. (Instruments and microscopic pictures.)
I. Development of telescopes. (Originals and reproductions.)
K. Experimental telescopes for comparison.
L. Double telescopes. (Instruments, partly sectional.)
M. Forms of lenses and prisms. (Specimens.)

Optics of More Recent Times

A. Velocity of light and brightness of light. (Pictures, models, instruments.)
B. The eye and its defects. (Diagrammatic drawings, reproductions of models of the eye, new models, instruments.)
C. Demonstration of spectacles. (Also models of the eye, pictures, and a collection of spectacles.)
D. Stereoscopic vision, permanence of the light impression, afterimages and contrast phenomena. (Instruments, demonstration and arrangement.)
E. Original instruments of Helmholtz.
F. Original instruments of Fraunhofer.
G. Spectrum apparatus of Kirchhoff and Bunsen.
H. Development of the theory of colors. (Historical survey, reproduction of experimental arrangement, demonstrations.)
I. Development of spectrum analysis. (Instruments and demonstrations.)
K. Interference diffraction, polarization, and the wave theory of light. (Historical survey, drawings, instruments, models, demonstrations.)
L. Manufacture of optical instruments. (Drawings and specimens; machines.)

Heat and Meteorology

A. The various kinds of temperature measurement. (Demonstrations.)
B. Development of the thermometer. (Instruments.)
C. Expansion of solid, liquid, and gaseous bodies. (Drawings and reproductions of instruments.)
D. Measurement of heat quantities. Melting and vaporizing. (Instruments, drawings, experimental arrangements, tables, models.)
E. Heat of combustion of various bodies. (Instruments and quantitative specimens of fuels.)

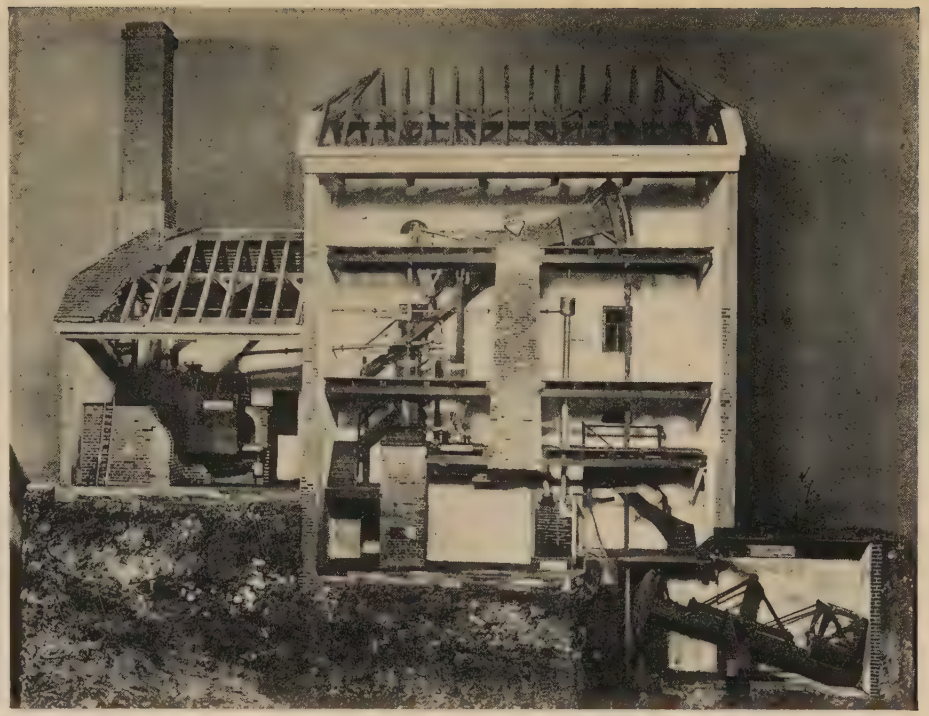
F. Radiation and conduction of heat. (Drawings, instruments, demonstration.)
G. Experiment of Rumford on the conversion of work into heat. (Model of experiment.)
H. Original apparatus of Robert Mayer.
I. Determination of the mechanical equivalent of heat. (Drawings and instruments.)
K. Apparatus and method for the liquefaction of gases. (Instruments and drawings.)
L. Original machine of Linde for liquefaction of air. (Original drawing and plant capable of operation.)
M. Demonstrations of liquid air.
N. Development of meteorological instruments. (Tables, pictures, instruments.)
O. Modern meteorological station. (Group of instruments capable of operation; charts.)

Wave Theory

A. Illustration of waves. (Demonstrations; wave machines.)
B. Stationary waves in solid bodies, liquids, and gases. (Demonstrating instruments.)
C. Lissajour figures. (Demonstration.)
D. Resonance phenomena. (Instruments and experimental arrangements.)
E. Reflection of waves. (Experimental arrangements.)
F. Refraction of waves. (Demonstrations.)
G. Interference of waves. (Demonstration apparatus.)
H. Polarization of waves. (Demonstrations, drawing.)
I. Absorption of waves. (Drawing.)

Acoustics

A. Pitch and intensity of sound. (Instruments, explanations, drawings, models.)
B. Tones of strings. (Historical survey, monochords.)
C. Tones of bars and plates. (Illustrative tuning forks and plates.)
D. Pipes. (Illustrative and experimental pipes.)
E. Dissociation of a sound into simple tones. (Instruments for demonstration.)
F. Development of the scale. (Simple presentation with pianino for playing of melodies.)
G. Knowledge about speech. (Sectional model and instruments.)



Deutsches Museum. Model of Watt's single acting pumping engine of 1813.

H. Knowledge about hearing. (Drawings and models.)
I. Testing of hearing. (Tuning-fork series, etc.)
K. Reproduction of tones by means of the phonograph, gramophone, and telegraphone. (Instruments and records.)

Frictional and Contact Electricity

A. Fundamental experiments.
B. Older electrostatic machines. (Machines and pictures.)
C. Electrostatic machine with battery of Leyden jars, used by Ohm.
D. Leyden or Kleist jars. (Specimens.)
E. Electrophoruses. (Specimens.)
F. Influence machines. (Specimens.)
G. Steam electrostatic machine.
H. Influence machine of Voss.
I. Demonstrations of static electricity.
K. Electroscope and electrometer. (Instruments.)
L. Investigation of aerial electricity. (Pictures and models.)
M. Frog's leg experiment of Galvani. (Demonstration.)
N. Voltaic pile. (Reproduction.)
O. Galvanic cell. (Collection of cells.)
P. Thermoelectric instruments. (Specimens.)
Q. Original instruments of Ohm.
R. Fundamental laws of Ohm and Kirchhoff. (Pictures and instruments.)
S. Current branching in liquids. (Pictures.)
T. Resistance standards. (Specimens.)
U. Instruments for measuring resistance.

Magnetism and Electric Current

A. Natural magnets and steel magnets. (Specimens and pictures.) Magnetic lines of force. (Pictures.)
B. Compasses. (Pictures and instruments.)
C. Instruments for the measurement of terrestial magnetism. (Instruments and charts.)
D. Earth inductor of Weber, 1853. (Demonstration instrument; inductor of Weber, partly original.)
E. Instruments for the investigation of magnetic variations. (3 instruments.)
F. Electromagnets. (Magnets, diagrams, measuring instruments.)
G. Demonstration electromagnet.

H. Solenoids. (Demonstration arrangement, original instruments.)
I. Original instruments of Ampère.
K. Application of the electromagnetic and electrodynamic laws. (Instruments.)
L. Galvanometers. (Series of instruments showing development.)
M. Development of induction instruments. (Demonstration, reproductions, instruments.)
N. Demonstration of the spark phenomenon in an inductor. (Apparatus.)
O. Demonstration of the Thomson effect. (Demonstration arrangement.)
P. Demonstration of eddy currents.
Q. Demonstration of Tesla currents.

Electric Radiations and Waves

I. Production of Electric Radiations

A. Development of vacuum tubes. (Original tubes and reproductions of tubes.)
B. Demonstration of the appearance of light in vacuum tubes. (Demonstrations in dark cabinets.)
C. Demonstrations in a variable vacuum. (Demonstration of the effect of a gradually produced vacuum.)
D. Demonstrations with Röntgen rays. (Screen and X-ray apparatus in dark room.)
E. Original tubes and original photograms of Röntgen.
F. Ionization of the air. (Instruments.)
G. Investigation of radium. (Experimental arrangements, instruments, specimens of radio-active substances.)

II. Investigation and Application of Electric Waves

H. Original oscillation apparatus of Feddersen.
I. Original apparatus of Bezold. (Also a number of dust figures on hard rubber plates.)
K. Original apparatus of Lecher, 1891.
L. Original pieces of apparatus of Hertz. (Also pictures of other apparatus of Hertz.)
M. Historical pieces of apparatus for the investigation and utilization of electric waves. (Also wiring diagrams.)

Deutsches Museum. Scenic groups illustrating the development of aeroplane construction.

N. The transmitting instruments of wireless telegraphy. (Pictures, originals, and auxiliary apparatus. Possible operation of an instrument that acts on the receiving apparatus under "O".)

O. The receiving instruments of wireless telegraphy. (Instruments and tuning devices, etc.)

P. Instruments for wireless telephony. (Originals, and complete transmitting and receiving sets, etc.)

Telegraphy

A. Development of optical telegraphy. (Drawings and models.)

B. First electrical telegraph of Sömmerring, 1809. (Original.)

C. Electrical needle telegraphs. (Reproductions and an original instrument.)

D. Electrical needle telegraphs. (Original instruments; drawing by Siemens.)

E. Earliest writing telegraph of Steinheil, 1836. (Original.)

F. Historic development of the Morse recording instruments. (Reproduction and originals; also automatic sending instruments.)

G. Development of cable telegraphy. (Two instruments.)

H. Type printing instruments. (Instruments and demonstration model.)

I. Copying telegraph of Casselli. (Reproduction of instrument; original telegram.)

K. Development of copying telegraphs and of automatic high-speed telegraphs. (Instruments, photographs, explanatory model.)

L. Calling contrivances. (Specimens.)

M. Auxiliary equipment for telegraph construction. (Objects.)

N. Materials and designs for the construction of lines. (Cross-sections of cables, etc.; model of a cable twisting machine.)

O. Abolition of the charge phenomena in telephone lines by Pupin coils. (Demonstration by operating telephone line.)

Telephony

A. Development of the telephone and microphone. (Diagrammatic drawings, original instruments, reproductions, telephone connection with the Royal Opera.)

B. Telephone stations. (Specimens.)

C. Switchboards and multiple switchboards for telephone central offices. (Originals and demonstration multiple switchboard.)
D. Automatic switching system of Strowger. (Demonstration arrangement for 4 stations.)
E. Semi-automatic switching system of Dr. Steidle.
F. Original telegraphones of Poulsen, 1898.
G. Talking arc lamp, at the same time transmitter of light telephony. (Demonstration installation, operating in conjunction with receiving antenna.)

Painting

A. Material and technique of painting in antiquity. (Originals and reproductions of paintings; implements for encaustic painting; reconstruction attempts shown next to originals.)
B. Material and technique of painting in the Middle Ages. (Original paintings and reproductions; Oriental paintings; miniatures on ivory and copper; samples of pigments.)
C. Material and technique of painting of more recent times. (Sixteenth and seventeenth centuries; fresco, oil, pastel, tempera technique; stereochromy and mineral painting; specimens of restorations.)
D. Material and technique of modern painting. (Colors shown in the form of powder as well as rubbed in oil; binders and their raw materials; implements; methods of testing for quality and permanence.)
E. Representation of porcelain painting. (Originals and reproductions of partially and wholly completed objects.)
F. Representation of glass painting. (Specimens of colored glass; combination picture; names of the most famous glass painters on the frame of the "tableau".)
G. Examination of paintings. (Charts showing results of microscopic and microchemical investigations.)

Writing and Printing

I. Writing

A. How one writes. (Series of pictures of people writing; specimens of writing; charts of characters.)
B. Technique of writing. (Implements and writings of many nations and ages, of various materials; development of the steel pen and the pencil.)
C. Development of typewriters. (Series of operable models.)

Deutsches Museum. Hall of Music.

II. Printing

D. Casting of type by hand and by means of machines. (Machines and specimens.)

E. Hand composition. (Stands, cases, implements, specimens of composition, proofsheets, etc.)

F. Development of the typesetting machine. (Original machines, pictures; specimens of machine composition.)

G. Stereotyping. (Earlier and more recent apparatus.)

H. Typical printed matter. (Originals and facsimiles of printed matter from the fifteenth century down to the present. Pictures of printing plants from the fifteenth century on.)

I. Earliest wooden hand presses. (Original, reproduction, photograph.)

K. Development of iron hand presses. (Pictures, original.)

L. Earliest high-speed press of König. (Reproduction, with a picture, drawings, and letters of the inventor.)

M. More recent high-speed presses. (Model; movable model.)

Printing of Illustrations, and Photography

I. Drawing

A. Development of mechanical drawing. (Instruments, drawings.)

II. Printing of Illustrations

B. Old and new methods of making woodcuts. (Prints and woodcut plates.)

C. Metal etching. (Original cuts and prints; also production of halftones with gratings.)

D. Old and new copperplate printing methods. (Drawings showing various methods; hand-presses, implements, materials; stages of development of a heliogravure.)

E. Technique of lithography. (Presses, implements, original lithographs; representation of the most important processes.)

F. Phototypy. (Original prints; presentation of the process in its stages of development.)

G. Color printing. (Specimens of older productions; modern light filters, partial negatives, grating copies, printing scales, finished specimens.)

III. PHOTOGRAPHY

H. Development of the photographic camera. (Original cameras of various types; demonstration of processes by automatic camera with visible interior.)

I. Photographic objectives. (Specimens, sectional drawings, specimen pictures, and text. Also wide-angle and telephoto lenses, automatic shutters, models of focal plane and diaphragm shutters.)

K. Photographic negative processes. (Originals of old negatives; comparative photographs; series of negatives and diapositives showing the effect of varying exposure, development, intensification, and reduction.)

L. Photographic positive processes. (Series of daguerreotypes, ferrotypes; copies and originals in various processes; enlargements and reductions; microphotographs; etc.)

M. Cinematography. (Series of examples of apparatus; films.)

N. Color photography. (Photographs, charts.)

TIMEPIECES

A. Sun, water, oil, and sand clocks. (Typical originals; demonstration model.)

B. Development of wheel clocks. (Models of various types of escapement; clocks, special clocks, chronoscope.)

C. Tower clocks. (Clockworks and tower clock.)

D. Modern tower clock of the year 1905. (Specimen.)

E. Historical development of watches with fuse escapement. (Specimens.)

F. Further development of watches with cylinder, duplex, anchor, and chronometer escapement. (Large-scale operating models of various escapements; original watches; special watches; drawing of watch parts.)

G. Development of pneumatic and electrical clocks. (Specimens.)

H. An old Schwarzwald clockmaker's workshop. (Working tools; collection of parts and clocks.)

I. Timepiece manufacture with machine operation. (Originals capable of operation; tableau with the separate parts of an alarm clock, showing total time of manufacture.)

Spinning

I. Spinning Fibers and Their Treatment

A. Vegetable fibers. (Specimens of flax, hemp, jute, ramie, Egyptian and American cotton—unprepared and prepared.)

B. Animal fibers. (Specimens of long-fiber sheep's wool, short-fiber sheep's wool, Mongolian camel's hair, raw silk, all in various stages; also stages of development of silkworms; silk unrolled from a cocoon; resuls of tests of food for silkworms.)

C. Mineral fibers and artificial fibers. (Specimens of asbestos, Cyprian gold threads, spun gold for brocade, artificial silk, spun material made from paper, cocoanut fibers, peat, and maize; also sample of a dress made of cocoanut fibers.)

II. Preparatory Machines and Preparatory Implements

D. Preparatory machines for wool and cotton of Arkwright, Heilmann, Gessner, etc. (Reproductions of machines.)

E. Preparatory implements for flax. (Implements; also model of an Upper Bavarian flax-breaking room, as well as pictures of machines to replace implements.)

III. Hand Spinning

F. Spindles and hand spinning wheels. (Originals, reproductions, pictures.)

G. Spinning wheels for continuous process. (Originals and reproduction.)

H. Yarn winding apparatus. (Specimens.)

Spinning, Twisting, and Sewing

I. Intermittent Spinning Machines

I. Earliest spinning jenny for manual operation, 1764. (Reproduction.)

K. Mule spinning jennys for manual and machine operation. (Reproduction and original.)

L. Original of a modern self-acting mule of the Elsässische Maschinenbaugesellschaft, Mulhausen. (Machine.)

II. Constant Spinning Machines

M. Water spinning frame. (Reproduction of original.)

N. Ring spinning frame. (Machine and collection of ring spindle forms.)

III. Braiding and Twisting

O. Twisting machines. (Machines; among them certain originals.)

IV. Sewing

P. Historic sewing machines, with a collection of prehistoric needles. (Originals and pictures of sewing machines.)

Q. More recent sewing machines. (Machines; large model; enlarged models for explanation of stitch formations, with the same parts in original size.)

Weaving

I. Hand Weaving

A. Looms of various ages and peoples. (Originals and pictures.)

B. Old hand looms.

C. Old weaving room with hand Dobby loom and all auxiliary implements for the preparation of the fabric threads, longitudinal and transverse threads. (Warp and woof threads.)

D. Experimental model for explanation of Jacquard weaving.

E. Reproduction of the first hand loom of Jacquard, 1808. (Also Jacquard picture fabrics of silk.)

II. Mechanical Weaving

F. Reproduction of the first mechanical cloth loom of Schönherr, 1836. (Also model, capable of operation, of an older mechanical cotton loom.)

G. Original of a modern silk loom with Dobby loom.

III. Specimens of Fabrics

H. Typical fabrics of various ages and countries. (Specimens.)

I. Diagrammatic representation and specimens of the principal kinds of fabric interweavings, from the simplest linen interweaving to velvet. (Patterns on an enlarged scale; drawings and models of inter-weavings; cross-sections of fabrics; specimen fabrics.)

Deutsches Museum. Development of the plough.

Farming

Treatment of the Soil, Nourishing of Plants, and Fertilizing

A. Development of plows and harrows. (Models on an arable field, showing attachment of motive power and mode of operation.)
B. The development of agriculture. (Shows steps from unsystematic agriculture to rotation of crops and intensive cultivation.)
C. Potato harvesting machines. (Machines and models.)
D. An arable field with models of sowing machines.
E. Seed scattering devices. (In original size and capable of operation.)
F. Plant nourishment. (Drawings and experimental arrangements; collection of profiles of German arable fields.)
G. Discovery and utilization of artificial fertilizers. (Pictures, fertilizer products.)
H. Intensive cultivation of grain. (Specimens of grain.)
I. Charts relating to the utilization of artificial fertilizers.

Harvesting and Stock-Raising

A. Development of mowing machines for grass and grain. (Machines, pictures, movable models on a field of grain.)
B. Hand implements for mowing and threshing from various ages and various peoples. (Reproductions and pictures.)
C. Threshing machines. (Pictures, models, machines.)
D. Model of the earliest straw press of Klinger.
E. Cleaning and sorting machines for grain. (Models and pictures.)
F. Feed appliances. (Models and pictures.)
G. Stable appliances of older and more recent times. (Showing development and resulting improvement in stock-raising.)
H. Stable arrangements. (Models and drawings, showing gradual improvement.)
I. Stock-raising. (Pictures and models showing higher yields from improvement.)

The Dairy Industry

A. Model of an old dairy.
B. Dairy implements of various ages and countries. (Models, reproductions, modern originals; pictures.)
C. Milk separators with their appurtenances, from the earliest primitive devices down to the present. (Machines, etc.)
D. Model of a modern dairy and creamery.
E. Creamery products. (Products, drawings, models, reproductions of cheese varieties.)
F. Constituents of milk. (Charts and drawings; exhibits of substances.)
G. Examination of milk. (Experimental arrangements; instruments.)

Fermentation Industry

I. Brewing

A. Brewing materials and beer analyses. (Specimens.)
B. Diagrammatic picture of a brewery.
C. Malting apparatus. (Pictures and models.)
D. Brewing-house apparatus. (Pictures and models.)
E. Investigation of yeast with apparatus of Hansen for the pure culture of yeast. (Development forms of yeast, magnified 500 times; instruments.)
F. Cellar arrangements. (Pictures and models.)
G. Instruments and apparatus for examination of raw materials and beers. (Specimens.)
H. Model of the old "Spaten" Brewery of the year 1812.
I. Model of a brewery with machine operation.
J. Picture of a modern brewery, with statistical data.
K. Model of a modern brewing-house.

II. Distilling

A. Originals of old spirits-distilling apparatus.
B. Experimental apparatus for explanation of distillation. (Operating model; diagrammatic model.)
C. Raw products of the manufacture of alcohol and spirits, and diagrammatic representation of their treatment. (Specimens; diagrammatic representation; pictures and models.)

D. Models of distilling apparatus for grain and potato distilleries, first half of nineteenth century. (Models and pictures.)

E. Model of a steam potato distillery with a Pistorius apparatus, 1846.

F. Modern columnar distilling apparatus of Avenarius, for continuous operation. (Apparatus; pictures.)

G. Model of an automatic distilling and rectifying apparatus of Ilges, 1906.

H. Model of a modern distillery.

I. Pieces of apparatus for examination of the raw materials and of the alcohol. (Specimens.)

Chemical Industry

I. Dye Industry

A. Natural organic dyes. (Specimens.)

B. Indigo factory. (Model of plant for artificial indigo.)

C. Production of coal tar dyes. (Diagrammatic representation of manufacture of fuchsin and banzopurpurin, with sectional models and specimens of material at each stage.)

D. Coal tar oils. (Specimens; pictures of apparatus.)

E. Genealogical table of coal tar dyes. (Specimens in glass, arranged in "family-tree" style to show derivation; also dyed samples in cotton or wool.

II. Soda Industry

F. Natural soda. (Pictures and preparations.)

G. Manufacture of soda according to Leblanc, 1791. (Model of a modern factory.)

H. Manufacture of soda according to Solvay. (Series of models.)

I. Caustic soda by means of electrolysis. (Model of plant.)

III. Acid Industry

K. Production of nitric acid from Chile saltpeter. (Pictures, and model of a modern factory.)

Process of direct combination of the nitrogen and oxygen of the air by means of the electric arc. (To be shown by models and experimental arrangements.)

L. Earliest production of sulfuric acid. (Pictures, models, original retorts.)

M. Manufacture of sulfuric acid according to the lead chamber process. (Model.)

N. Manufacture of sulfuric acid according to the contact process. (Model.)

IV. Diagrammatical Representations of a More General Nature

O. Important elements and their compounds. (Collection of specimens in glass, arranged so that the compounds are located at the intersection of the horizontal and vertical lines leading from the constituent elements.)

P. Production of chemical products from the raw materials. (Specimens of products in glass, with intermediate products, connected with colored cords to show derivation—see Fig. 42.)

Q. Manufacture of cellulose. (Model of sulphite plant, complete.)

Alchemist's Laboratory

A. Substances known in antiquity. (Collection of substances; reproduction of a Roman balance; charts with pictures of distilling implements; original glass vessels.)

B. Ancient metallurgy. (Reproductions: furnace, bellows, implements.)

C. Discoveries of the Middle Ages. (Specimens of substances.)

D. Distilling apparatus. (Specimens.)

E. Sand-bath hearth with an old pelican, etc. (Specimens, with an original "pelican.")

F. Paracelsus and Basilius Valentinus. (Exhibit of substances mentioned by them for the first time, shown above an old water-bath.)

G. Agricola and Ercker. (Table with testing implements.)

H. Iatrochemical discoveries. (Preparations; reproductions of pieces of apparatus.)

Chemical Laboratory of the Eighteenth Century

A. Pieces of apparatus from the phlogistio period. (Reproductions of characteristio experimental arrangements.)

B. Chimney according to Lavoisier. (Reproduction.)

Deutsches Museum. Laboratory of an alchemist.

C. Analytical reagents. (Collection of specimens.)
D. Decomposition of water according to Lavoisier. (Reproduction of Lavoisier's apparatus.)
E. Pieces of apparatus according to Lavoisier. (Reproductions.)
F. Chimney according to Priestley. (Reproduction.)
G. Reverberating furnace. (After Lavoisier.)
H. Important substances discovered in the phlogistic age. (Specimens in cabinet; also original specimens and an old "Kunkelglas.")

Liebig Laboratory

Reproduction of laboratory which Liebig caused to be fitted up at Giessen in 1839.

A. Sand bath according to Liebig.
B. Liebig coolers for condensation. (Large originals.)
C. Pieces of apparatus of Bunsen, Hofmann, etc. (Originals.)
D. Hood hearths according to Liebig. (Exact reproductions; one is sectioned in two directions; a number of original objects of Liebig's on the hearths.)
E. Pieces of apparatus and experimental arrangements according to Liebig. (Originals and reproductions.)
F. Apparatus for organic analysis. (Several pieces, one original.)
G. Original pieces of apparatus of Mitscherlich, etc.
H. Preparations from the first half of the nineteenth century. (Specimens with names of discoverers; original gas lamps and burners of Bunsen.)

Modern Laboratory

A. Collection of the elements. (Nearly complete series in historical sequence.)
B. Rare earths. (Specimens of these and their compounds; some valuable original preparations; also collection of synthetic jewels.)
C. Important preparations of more recent times. (Original preparations; other specimens.)
D. Precision balances. (Specimens.)
E. Work table with analytical apparatus and reagents.
F. Hoods of a more recent type, with a series of pieces of apparatus for production of gases.

G. Apparatus for organic analysis. (Under an open hood.)
H. Apparatus for physical chemistry. (Specimens, partly originals.) Atom models. (Originals.)
I. Testing apparatus for demonstration. (Demonstration of qualitative analysis; pulling handles causes mixture of 2 solutions and precipitation, showing presence of iron. Also diagrammatic representation.)

Electrochemistry

A. Galvanic baths. (Specimens.)
B. Galvanoplastics. (Specimens of galvanic art; series showing production stages.)
C. Bust of Bunsen.
D. Scientific apparatus. (Pieces of apparatus and models; decomposition of water by means of electricity can be demonstrated by the visitor's turning a switch.)
E. Electric furnaces. (Specimens of important types.)
F. Electrochemical metallurgy. (Apparatus and models of furnaces.)
G. Kiliani furnace.
H. Production of calcium carbide. (Model of a furnace and an original anode carbon.)

Hydraulic Engineering

I. Hydrotechnical Observation

A. Measuring instruments. (Instruments and models.)
B. Hydrographic maps. (Reproduction of an old map; other river maps; plastic representation of water speeds.)

II. Regulation of Watercourses

C. Flood catastrophes and damming of torrents. (Pictures and photographs showing damage from floods; drawings and models and a picture of control dams.)
D. River control systems. (Drawings and models.)

III. Dam Structures

E. Development of fixed weirs and dams across valleys. (Pictures.)
F. Movable weirs. (Drawings and models; pictures.)
G. Earliest cylinder weir. (Model capable of operation.)

IV. Entire Construction Undertakings

H. Regulation of the Vienna River. (Model.)

I. Water constructions at Schweinfurt. (Model with explanatory drawings.)

K. Site at the correction of the Lower Weser. (Model of machines and arrangements.)

V. Construction Machines

L. The development of dredgers. (Models and pictures.)

Internal Navigation

A. Development of river boats. (Models.)

B. Towboats. (Pictures.)

C. Towboat of Maréchal de Saxe, 1732. (Model.)

D. Model of a Danube barge. (Model of normal type.) Model of a petroleum tanker.

E. Cable and chain navigation. (Pictures and models.)

F. Maps of German waterways. (Two maps.)

Canal Construction

I. Ship Locks

A. Retaining lock of the Stecknitz Canal, 15th century. (Plans and pictures; also drawings and pictures of others.)

B. Chamber locks. (Model.)

C. Conservation lock of the Dortmund-Ems Canal. (Model.)

D. Model, capable of operation, of the Hotopp lock near Lübeck.

II. Ship Hoists

E. Development of inclined planes. Model of the inclined plane of the Elbing-Oberländischer Kanal. (Pictures, models, drawings.)

F. Plans of vertical ship hoists. (Pictures, drawings, model capable of operation.)

III. Canal Plans

G. Plans and pictures of inland canals. (Pictures, plans, maps.)

H. Sea canals: the Suez Canal. (Plan.)

H. Sea canals: Kaiser Wilhelm Canal at Kiel. (Representation.)

H. Sea canals: Panama Canal. (Two maps; relief.)

Shipping

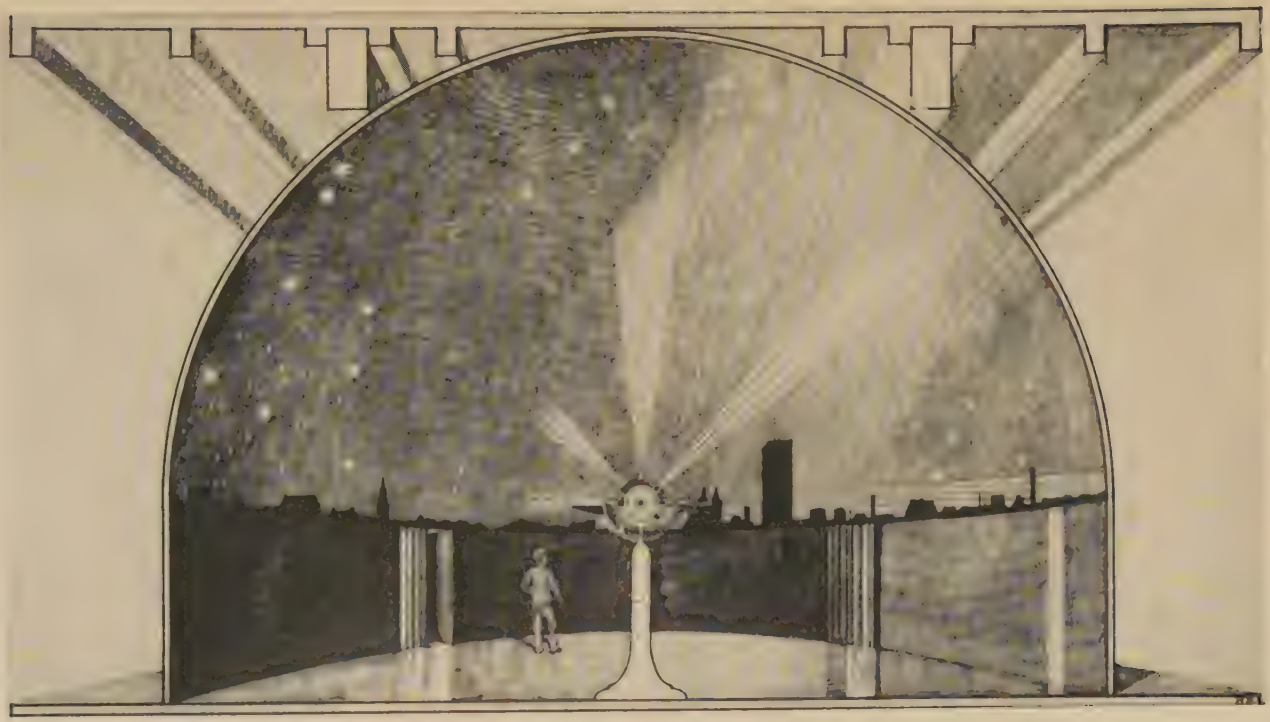
A. Models of sea marks. (Models; original lamp for gas buoys.)
B. Siemens searchlight.
C. Development of beacons. (Pictures, models, drawing.)
D. The various beacons for a watercourse. (Model.)
E. Building-slip plants. (Models.)
F. New dry dock of the Wilhelmshaven shipyard. (Model.)
G. Old wooden floating dock. (Model.)
H. Iron floating dock of Blohm & Voss. (Model.)

Merchant Ships

A. Rowboats and sailboats of primitive peoples. (Models and originals.)
B. Exotic ships. (Models of junks, etc.)
C. Mixed rowing and sailing vessels. (Models.)
D. Galley Bucentaur. (Reconstruction model.)
E. Sail yachts. (Models.)
F. Old sailing vessels. (Models.)
G. More recent sailing vessels. (Models.)
H. The earliest steamships. (Models.)
J. More recent express steamships. (Models.)
K. Sectional painting of the express steamship "Kaiser Wilhelm II."
L. Development of paddle wheels. (Drawings and models; demonstration arrangements.)
M. Development of the propeller. (Models; 1 original propeller.)
N. Special ships. (Half-model of a tanker; models of ice-breakers, fishing vessels, cable ships, ferryboats, etc.)

Warships

A. Old warships, broadside battleships, frigates, and corvettes. (Pictures and models.)
B. Small cruisers. (Models.)
C. Armored cruisers. (Models.)
D. Older battleships. (Models.)
E. More recent battleships. (Models.)
F. Sectional model of a battleship. (Details disclosed by sectional presentation.)
G. Modern huge battleship. (Model.)
H. Development of sea mines and torpedoes. (Drawings.)



Deutsches Museum. Ptolemaic planetarium.

I. Sectioned torpedo missile and torpedo discharge tube with missile. (Originals.)
K. Older and more recent types of torpedo boats. (Models and sectional drawing.)
L. Old and new submarines. (Models and sectional model.)
M. Periscope for submarines. (Original.)
N. Gunboats, ocean-going gunboats, and coast armored vessels. (Models.)
O. Instruments for the determination of location and time. (Instruments.)
P. Instruments for measurement of depth and speed. (Instruments and models.)
Q. Mechanical and electrical command signals. (Instruments, partly capable of operation.)
R. Charts relating to ships. (About naval strength.)
S. Cycle of paintings. (Development of ship construction.)

Library and Collection of Plans

Library

Contains particularly:—

The most important original works of former times on natural science and technics;
Modern scientific and technical literature, foreign and domestic;
Domestic and foreign periodicals and society publications;
Patents;
Dictionaries, legal and economic works, etc.

Collection of Plans

Contains:—

Portraits of eminent scholars and technicians;
Historically interesting hand sketches of scientists and technicians;
Original plans of old machines, plants, and instruments;
Pictures disclosing development of science and technology;
Plans of arrangement and execution of machines, instruments, structures, and entire plants;
Diagrammatic drawings, etc., for explanation of machines and structures;
A systematic collection of catalogues and prints;
A collection of photographs and diapositives of the objects exhibited in the museum.

Hall of Honor: Busts, etc.

APPENDIX 3

DEUTSCHES MUSEUM—MUNICH

STATEMENT OF ACCOUNT FOR OPERATION OF THE MUSEUM FOR THE YEAR 1913

Receipts

Classification	Budget	Actual Receipts	Excess or Deficiency
I. *Ordinary Receipts*	Marks	Marks	Marks
A. Annual subventions			
Subvention of the German Empire.	50,000.—	50,000.—	.....
Subvention of the Kingdom of Bavaria	50,000.—	50,000.—	.....
Subvention of the City of Munich	15,000.—	15,000.—	.....
Subvention of the District of Upper Bavaria	6,000.—	6,000.—	.....
Subvention of the Senate of Hamburg	5,000.—	5,000.—	.....
Subvention of the City of Berlin	3,000.—	3,000.—	.....
Subvention of the Verein Deutscher Ingenieure	5,000.—	5,000.—	.....
Subvention of the Zeppelin foundation	5,000.—	5,000.—	.....
Subvention of the Union of Bavarian Metal Manufacturers..	3,000.—	3,000.—	.....
Subvention of the Jubilee Foundation of German Industry	2,000.—	2,000.—	.....
Subvention of the Central Union of German Manufacturers	1,000.—	1,000.—	.....
Subvention of the Augsburg Industrial Society	1,000.—	1,000.—	.....
Subvention of other authorities, corporations, etc.	15,000.—	14,416.05	— 583.95
	161,000.—	160,416.05	— 583.95
B. Membership dues	60,000.—	63,043.71	+ 3,043.71
	60,000.—	63,043.71	+3,043.71
C. Admission fees and receipts from printed matter, etc.	50,000.—	49,155.40	— 844.60
Period tickets	2,000.—	2,121.—	+ 121.—
Student cards, lecture and guidance tickets	3,000.—	4,884.90	+1,884.90
Sale of guides, post cards, etc. ...	9,000.—	9,911.68	+911.68
	64,000.—	66,072.98	+ 2,072.98
Total of ordinary receipts ..	285,000.—	289,532.74	+ 4,532.74
II. *Extraordinary Receipts*			
A. Surpluses from preceding years	374,606.51	374,606.51	.....
B. Single contributions for museum objects or other special purposes, etc.	26,000.—	61,272.63	+ 35,272.63
C. Interest from endowment funds	130,000.—	176,009.74	+ 46,009.74
Total of extraordinary receipts..	530,606.51	611,888.88	+ 81,282.37

STATEMENT OF ACCOUNT FOR OPERATION OF THE MUSEUM FOR THE YEAR 1913

Expenditures

Classification	Budget	Actual Expenditures	Excess or Deficiency
I. *Ordinary expenditures*	Marks	Marks	Marks
A. Personal expenditures			
Shares of salaries and wages, in so far as they were expended for operation of the Museum:			
For scientifically trained officials: engineers, physicists, mathematicians, chemists	36,000.—	31,808.—	— 4,192.—
For librarians and assistants	10,000.—	9,306.—	— 694.—
For administrative officials, business employees, clerks	18,000.—	16,908.70	— 1,091.30
For painters, sculptors, draftsmen	7,000.—	7,000.—	.....
For mechanicians, furnace-men, lighting attendants	9,000.—	9,924.85	+ 924.85
For office and library attendants, custodians, superintendent, night watchmen	82,000.—	78,230.65	— 3,769.35
For cleaning and polishing service	6,000.—	4,568.70	— 1,431.30
	168,000.—	157,746.90	— 10,253.10
B. Material expenditures			
Maintenance of the buildings	5,000.—	2,636.62	— 2,363.38
Maintenance and repair of the museum objects and equipment.	7,000.—	4,122.17	— 2,877.83
Heating and lighting	35,000.—	28,920.04	— 6,079.96
Printed matter	10,000.—	8,212.20	— 1,787.80
Materials, implements, miscellaneous	6,000.—	5,931.37	— 68.63
Postage, telegrams, telephone	3,000.—	3,271.63	+ 371.63
Traveling expenses	3,000.—	2,307.61	— 692.39
Expenditures for meetings of the Vorstandsrat and the Committee, as well as for special functions	5,000.—	4,148.27	— 851.73
Public duties, taxes, tax stamps, insurance	16,000.—	12,113.89	— 3,886.11
Miscellaneous and unforeseen items	8,000.—	8,105.43	+ 105.43
	98,000.—	79,769.23	— 18,230.77
C. Current supplementing of the collections			
Purchase of museum objects	10,000.—	10,000.—	.....
Production of models and pictures in the museum's own shop	3,000.—	3,000.—	.....
Books, drawings, including bookbinding	3,000.—	3,000.—	.....
Exhibition cases, shelves, operating equipment	3,000.—	3,000.—	.....
	19,000.—	19,000.—	.....
Total of ordinary expenditures	285,000.—	256,516.13	— 28,483.87

Classification	Budget	Actual Expenditures	Excess or Deficiency
II. *Extraordinary expenditures*	Marks	Marks	Marks
A. Personal expenditures			
Shares of salaries and wages for the initial arrangement of the various divisions of the Museum:			
For engineers, physicists, etc. ...	10,000.—	3,142.24	— 6,857.76
For administrative officials, business employees, clerks	6,000.—	2,455.70	— 3,544.30
For painters, sculptors, draftsmen, painters of lettering	10,000.—	7,767.93	— 2,232.07
	26,000.—	13,365.87	— 12,634.13
B. Subventions			
Transfer to the relief fund ...	6,000.—	4,938.—	.....
Transfer to employees		1,062.—	.....
	6,000.—	6,000.—	.....
C. Material expenditures			
Structural arrangements in the Old National Museum and in the Isarkaserne	10,000.—	5,436.07	— 4,563.93
Transportation of museum objects and pieces of equipment	5,000.—	1,755.26	— 3,234.74
Rent of the Isarkaserne	14,000.—	13,459.28	— 540.72
	29,000.—	20,660.61	— 8,339.39
D. Movables and exhibition objects			
Shelves, exhibition cases	14,000.—	3,010.08	— 10,989.92
Purchase of museum objects and books	27,000.—	24,416.—	— 2,584.—
Production of models and pictures in the Museum's own shop	14,000.—	10,921.28	— 3,078.72
	55,000.—	38,347.36	— 16,652.64
E. Publications	.....	2,870.—	+ 2,870.—
	.....	2,870.—	+ 2,870.—
F. Expenses for administration of the Traveling Foundation	3,000.—	3,850.76	— 149.24
	3,000.—	3,850.76	— 149.24
Total of extraordinary expenditures	119,000.—	84,094.60	— 34,905.40
Total of ordinary expenditures	285,000.—	256,516.13	— 28,483.87
Total of extraordinary expenditures	119,000.—	84,094.60	— 34,905.40
Grand total of expenditures.	404,000.—	340,610.73	— 63,389.27
Carried forward to new account	411,606.51	560,810.89	+ 149,204.38
Grand total of expenditures and accounts carried forward	815,606.51	901,421.62	+ 85,815.11

STATEMENT OF ACCOUNT FOR THE NEW BUILDING OF THE MUSEUM FOR THE YEAR 1913

Receipts

Classification	Budget	Actual Receipts	Excess or Deficiency
	Marks	Mark	Marks
Balance carried over from the preceding year	2,030,246.43	2,030,246.43	
Building Councillors of the German Empire	350,000.—	350,000.—	
Building Councillors of the Kingdom of Bavaria	.....	.....	
Building Councillors of the City of Munich	100,000.—	100,000.—	
Withdrawal from the endowments paid in	.....	.....	
Saving in consequence of presentation, or sale at a lower price, of building materials, the freedom from freight and paving taxes being taken into account..	99,753.57	91,103.11	— 8,650.46
Total Receipts	2,580,000.—	2,571,349.54	— 8,650.46

STATEMENT OF ACCOUNT FOR THE NEW BUILDING OF THE MUSEUM FOR THE YEAR 1913

Expenditures

Classification	Budget	Actual Expenditures	Excess or Deficiency
A. *Construction Office*	Marks	Marks	Marks
1. Salaries for director of construction, architects, engineers, draftsmen, and the like	70,000.—	59,372.11	— 10,627.89
2. Wages for foremen, supervisors, etc.	10,000.—	9,012.05	— 987.95
3. Rent for construction office	4,000.—	4,000.—	.....
4. General expenses for heating, lighting, office supplies, postage, as well as unforeseen items	10,000.—	6,935.44	— 3,064.56
5. Models and the like	5,000.—	15,837.17	+ 10,837.17
	99,000.—	95,156.77	— 3,843.23
B. *Equipment of the Site*			
Construction planking, construction sheds, storage sheds Track installation, roller paths, and means of transportation Construction engines, provisional light and power plants	10,000.—	365.38	— 9,634.62
	10,000.—	365.38	— 9,634.62
C. *Building Materials and Wages*			
Earth-work, street construction, leveling	15,000.—	.....	— 15,000.—
Foundation work	35,000.—	478.13	— 34,521.87
Concrete and reinforced concrete work	230,000.—	172,554.54	— 57,445.46
Masonry work	50,000.—	.....	—50,000.—
Stone-mason work	30,000.—	.....	— 30,000.—
Asphalt work and insulating work	20,000.—	.....	— 20,000.—
Carpentry work	40,000.—	4,767.37	— 35,232.63
Iron construction work	40,000.—	28,690.69	— 11,309.31
Roofers' and tinsmiths' work	100,000.—	145,177.50	+ 45,177.50
Miscellaneous finishing operations, joiners', locksmiths', and glaziers' work, etc.	100,000.—	586.31	— 99,413.69
	660,000—	352,254.54	— 307,745.46

Classification	Budget	Actual Expenditures	Excess or Deficiency
D. *Installations and Machine Plants*	Marks	Marks	Marks
Water piping and sewer pipes...	50,000.—	.....	— 50,000.—
Heating ventilation	80,000.—	.....	— 80,000.—
Operating equipment for gas, compressed air, air suction, etc.	60,000.—	.....	— 60,000.—
Illuminating plant	50,000.—	.....	— 50,000.—
Machine plants	80,000.—	.....	— 80,000.—
	320,000.—	.....	— 320,000.—
E. *Internal Equipment*	60,000.—	1,289.23	— 58,710.77
		1,289.23	— 58,710.77
F. *General Expenses, Miscellaneous and Unforeseen Items*	60,000.—		
General expenses		2,655.52	
Inheritance tax	51,000.—	4,580.05	— 43,764.43
	51,000.—	7,235.57	— 43,764.43
Total expenditures	1,200,000.—	456,301.49	— 743,698.51
Carried forward to new account	1,380,000.—	2,115,048.05	— 735,048.05
Total of expenditures and amount carried forward ..	2,580,000.—	2,571,349.54	— 8,650.46

BUDGET FOR THE NEW BUILDING OF THE MUSEUM FOR THE YEARS 1914 AND 1915

Receipts

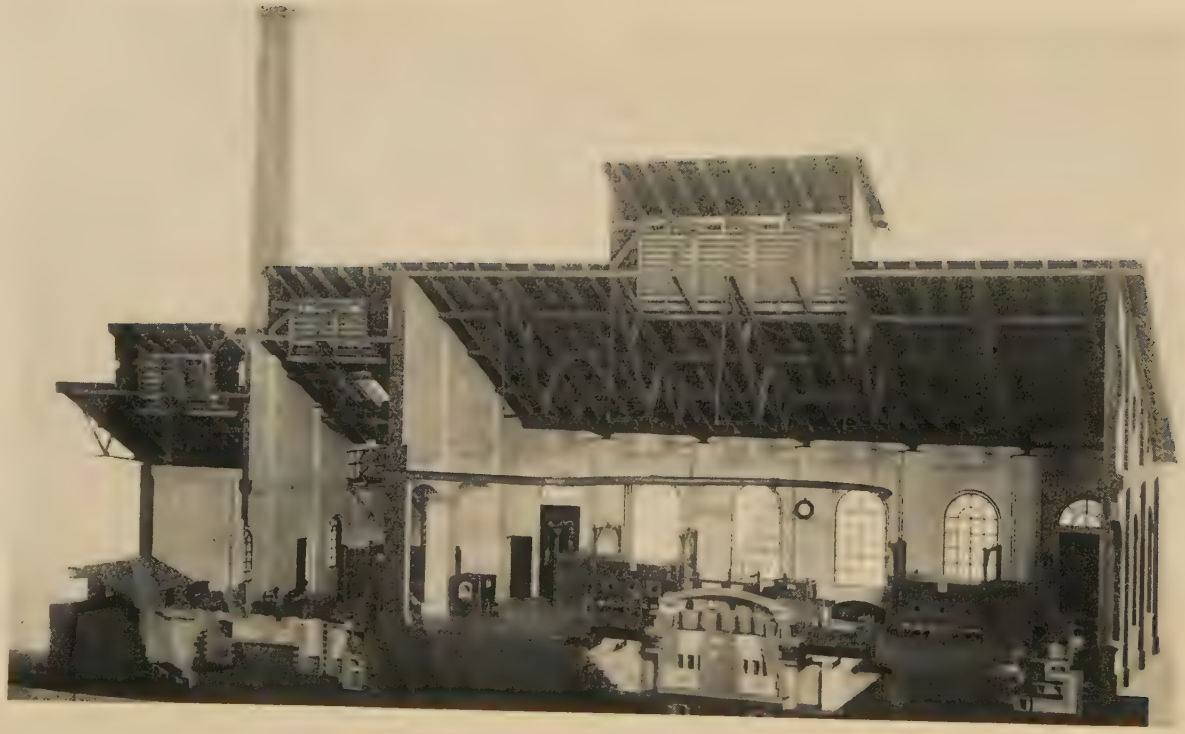
Classification	1914 Authorized	1914 New Proposal	1915
	Marks	Marks	Marks
Balance carried over from the preceding year	1,380,000.—	2,115,048.05	1,550,000.—
Building Councillors of the German Empire — the 2,000,000 marks originally granted have already been paid out	.....	.....	.....
Building Councillors of the Kingdom of Bavaria—the 2,000,000 marks originally granted have already been paid out	.....	.....	.....
Building Councillors of the City of Munich	100,000.—	100,000.—	.....
Withdrawal from the endowments paid in	.....	.....	.....
Saving in consequence of presentation, or sale at a lower price, of building materials, the freedom from freight and paving taxes being taken into account.	120,000.—	34,951.95	50,000.—
	1,600,000.—	2,250,000.—	1,600,000.—

BUDGET FOR THE NEW BUILDING OF THE MUSEUM FOR THE YEARS 1914 AND 1915

Expenditures

Classification	1914 Authorized	1914 New Proposal	1915
	Marks	Marks	Marks
A. *Construction Office*			
1. Salaries for director of construction, architects, engineers, draftsmen, and the like	70,000.—	70,000.—	90,000.—
2. Wages for foreman, supervisors, etc.	10,000.—	10,000.—	15,000.—
3. Rent for construction office	4,000.—	4,000.—	4,000.—
4. General expenses for heating, lighting, office supplies, and unforeseen items	10,000.—	10,000.—	10,000.—
5. Models, pictures, and the like	5,000.—	5,000.—	20,000.—
	99,000.—	99,000.—	139,000.—
B. *Equipment of the Site*			
Construction planking, construction sheds, storage sheds, track installation, roller paths, and means of transportation, construction engines, provisional light and power plants	10,000.—	10,000.—	10,000.—
	10,000.—	10,000.—	10,000.—
C. *Building Materials and Wages*			
Earth-work, street construction, leveling	30,000.—	20,000.—	25,000.—
Foundation work	70,000.—	35,000.—	70,000.—
Concrete and reinforced concrete work	200,000.—	100,000.—	150,000.—
Masonry work	50,000.—	30,000.—	60,000.—
Stone-mason work	25,000.—	25,000.—	30,000.—
Asphalt work and insulating work	25,000.—	15,000.—	30,000.—
Carpentry work	25,000.—	25,000.—	35,000.—
Iron construction work	45,000.—	35,000.—	35,000.—
Roofers' and tinsmiths' work	20,000.—	20,000.—	20,000.—
Miscellaneous finishing operations, joiners', locksmiths', and glaziers' work, etc.	150,000.—	100,000.—	150,000.—
	640,000.—	405,000.—	605,000.—

Classification	1914 Authorized	1914 New Proposal	1915
D. *Installations and Machine Plants*	Marks	Marks	Marks
Water piping and sewer pipes..	30,000.—	20,000.—	60,000.—
Heating and ventilation	20,000.—	10,000.—	90,000.—
Operating equipment for gas, compressed air, air suction, etc.	40,000.—	20,000.—	80,000.—
Illuminating plant	50,000.—	10,000.—	90,000.—
Machine plants	60,000.—	20,000.—	120,000.—
	200,000.—	80,000.—	440,000.—
E. *Internal Equipment*			
Movable objects	200,000.—	50,000.—	150,000. —
	200,000.—	50,000.—	150,000. —
F. *Moving Expenses*	.....	.....	50,000.—
			50,000.—
G. *General Expenses, Miscellaneous and Unforeseen Items*			
General expenses	51,000.—	56,000.—	56,000.—
Inheritance tax			
	51,000.—	56,000.—	56,000.—
Total expenditures	1,200,000.—	700,000.—	1,450,000.—
Carried forward to new account	400,000.—	1,550,000.—	150,000.—
Total of expenditures and amount carried forward ..	1,600,000.—	2,250,000.—	1,600,000.—



Technical Museum, Vienna. Model of pressed glass factory.

APPENDIX 4

TECHNICAL MUSEUM—VIENNA

Organization of the museum collections proposed by the Advisory Committee (Kollegium) June 1914

Group I: Soil Culture

1. Agricultural implements and machines.
2. Forestry engineering, damming of torrents, and treatment of wood.
3. Technology of cultivation.
4. Statistics.

Group II: Mining and Metallurgy

1. Technology of mining.
2. Iron and metal smelting.
3. Salt works and mineral oil industry.

Group III: Iron and Metal Industry

1. Iron and metal casting.
2. Machine tools.
3. Forging, pressing, and rolling-mill machines.
4. Sheet iron industry, forging, and locksmithing.
5. Expedients for the production of iron constructions and for the working of tin.
6. Stamping (coining) technology and working of precious metals.
7. Arms technology.

Group IV: Machine Construction

1. Steam and power-gas generators, water and wind motors.
2. Pumps, compressors, and blowers, refrigerating machines.
3. Hoisting machines and transportation plants, transmissions.

GROUP V. ELECTROTECHNICS

1. Sources of current, action and measurement of electric current (dynamos as such; primary, secondary, and thermo cells).
2. Generation and distribution of current (complete construction of electric central stations).
3. Electric illumination and heating (electricity in housekeeping).
4. Forms of motor drive.
5. High frequency currents.

GROUP VI: COMMUNICATION

1. Postal, telegraph, and telephone systems.
2. Railroading.
3. Shipping.
4. Automobile transportation and aviation.

GROUP VII: FUNDAMENTAL SCIENCES OF TECHNOLOGY

GROUP VIII: CHEMICAL INDUSTRY

1. Industry of inorganic chemistry, and
2. Industry of organic chemistry.

GROUP IX: FOOD AND TABLE-LUXURIES INDUSTRY

1. Sugar industry.
2. Manufacture of starch, alcohol, and compressed yeast.
3. Malting and brewing.
4. Preparation of wine, and wine storage.
5. Milling and baking.
6. Tobacco industry.

GROUP X: GRAPHIC INDUSTRY

1. Technology of drawings and of printing; writing and book-production.
2. Type casting, and typesetting machines.
3. Printing processes.
4. Photography and cinematography.
5. Photomechanical processes.
6. Cartography, photogrammetry, and aerophotography.
7. Bookbinding and binding in boards.

SUB-GROUP XA: ORGANIZATION AND OPERATION OF TECHNICAL ENTERPRISES.

GROUP XI: FIBER INDUSTRIES

1. Braiding.
2. Textile industry.
3. Leather industry.
4. Paper industry.

Technical Museum, Vienna. Styrian refinery.

GROUP XII: CLOTHING INDUSTRY

1. Production of men's and women's clothing, fur industry, production of underwear and corsets.
2. Production of hats, shoes, gloves, umbrellas and parasols, artificial flowers, and ornamental feathers.

GROUP XIII: INDUSTRY BASED ON ROCKS AND EARTHS

1. Procuring of raw materials and earths.
2. Mortar materials and artificial stone.
3. Ceramics.
4. Glass industry.

GROUP XIV: BUILDING

1. Building construction.
2. Foundations, road construction, and bridge construction.
3. Hydraulics engineering, water supply, and sewer construction.
4. City planning and settlement methods.

GROUP XV: HEALTH TECHNOLOGY

1. Hygiene of building and settlement.
2. Heating and ventilation, hygiene of natural and artificial illumination.
3. Water; sewage; vitiation of the air by gases, smoke, and dust; street dust; solid waste materials.
4. Technical expedients for the care of the body and care of children, for care of the sick, and for treatment of corpses.
5. Health resorts and mineral spring baths.

GROUP XVI: PROTECTION OF WORKERS

1. Protective devices in connection with the operating equipment generally employed in trade and industry.
2. Protective devices in connection with the special operating equipment of 13 different industry groups.
3. Industrial hygiene.
4. Protection of workers in mining operations.
5. Protection of workers in inland shipping.

GROUP XVII: FIRE-EXTINGUISHING AND LIFE-SAVING

1. Historic fire-extinguishing methods.
2. Modern fire-extinguishing technology.
3. Fire prevention and fire-alarm systems.
4. Life-saving aside from cases of fire.
5. Organization and statistics.
6. International library on this subject.

APPENDIX 5

TECHNICAL MUSEUM—VIENNA

Statutes

Rules made by the Federal Ministry for Trade, Industry, and Building (later known as the Ministry for Trade and Commerce.) Decree of December 30, 1921.

Purpose and Arrangement of Technical Museum

I. Museum is to represent the development of industry, to promote technical progress, and to be a place of education for the entire people. This purpose is served by the following arrangement:

1. The exhibit collections of the museum.
2. A technical library and archives, together with a collection of photographs and films.
3. Conducted tours and lectures.
4. Scientific papers and publications of a technical kind.
5. Technical department exhibits.
6. Other measures and arrangements which are calculated to serve the purposes of the museum.

Organization of the Museum

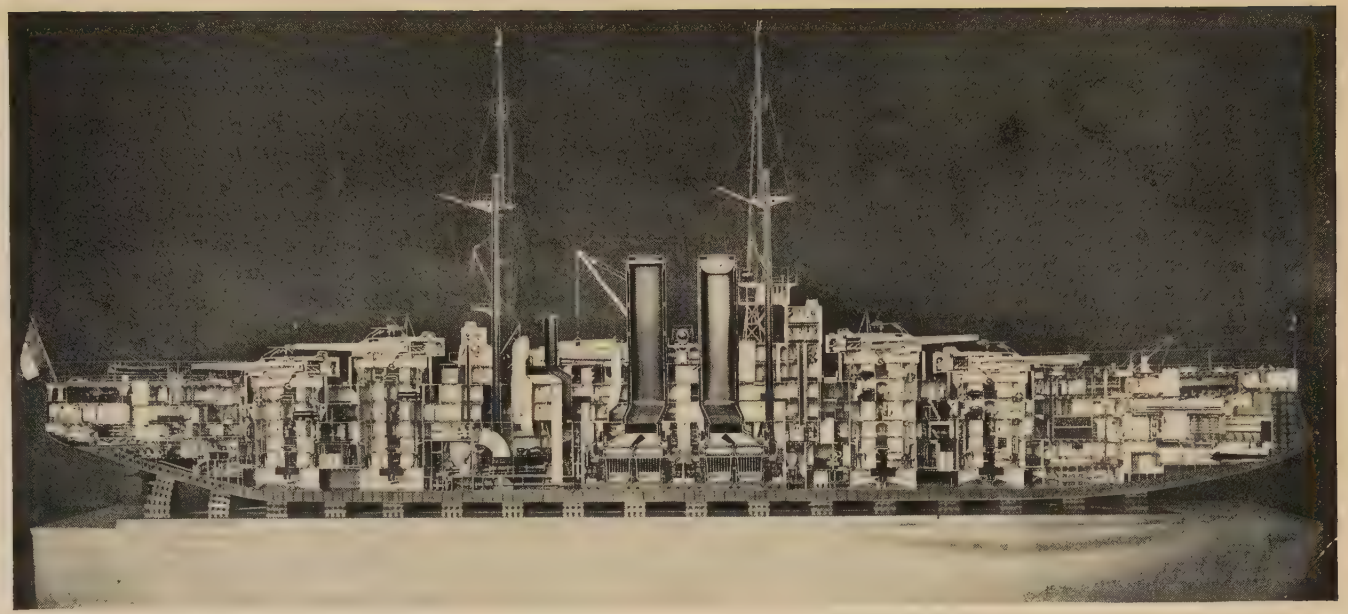
II. The Technical Museum is a Federal institution and is under the Federal Ministry for Trade, Industry and Building.

III. The museum management consists of:

1. The Kuratorium.
2. The Board of Directors.
3. The director of the museum.

Kuratorium

IV. The Kuratorium consists of the president and at most thirty members which are named by the Federal Ministry for Trade, Industry and Building. Five of these members each are named by the Federal Ministry for Trade, Industry and Building on the nomination of the municipality of Vienna and of the Society for the Promotion of the Technical Museum in Vienna.



Technical Museum, Vienna. Model of the "Viribus Unitis."

V. The members of the Kuratorium have the title "Kurator" of the Technical Museum in Vienna. Their period of service is three years. If a Kurator drops out during his term, the Federal Ministry for Trade, Industry and Building names some other person as a member of the Kuratorium for the rest of the term.

If the member of the Kuratorium was nominated by the municipality of Vienna or by the Society for the Furtherance of the Technical Museum, then the designation is effected on nomination of the municipality or society as appropriate.

VI. At the head of the Kuratorium there is a president named by the Federal president.

As substitutes for the president there act three vice-presidents who are named by the Federal Ministry for Trade, Industry and Building from among the members of the Kuratorium. One of the vice-presidents is to be appointed from each of the groups of those Kurators who have been nominated by the municipality of Vienna and by the Society for the Furtherance of the Technical Museum.

The term of the president and of the vice-presidents is determined by the term of the Kurators.

VII. The sphere of operation of the Kuratorium includes:

1. The rendering of opinions to the Federal Ministry for Trade, Industry and Building regarding the organization of the Technical Museum and regarding its arrangement.
2. The preparation of the draft of a business system that is to be issued by the Federal Ministry for Trade, Industry and Building for the Kuratorium and the Board of Directors.
3. The approval of the annual financial estimate of the museum and its submission to the Federal Ministry for Trade, Industry and Building.
4. The submitting of proposals regarding the appointment of members of the Board of Directors and regarding the appointment of the director of the museum to the Federal Ministry for Trade, Industry and Building.
5. The rendering of opinions regarding matters which are referred to the Kuratorium in individual cases for expression of opinion by the Federal Ministry for Trade, Industry and Building.
6. The designation of persons who have performed meritorious services for the Technical Museum by appointing them corresponding members of the museum; the resolutions in question require for their validity the confirmation of the Federal Ministry for Trade, Industry and Building.

VIII. The Kuratorium is summoned by the president according to requirements, but at least once a year. The president or one of the vice-presidents is in the chair. The Kuratorium has a quorum if at least ten members are present including the chairman. In case of a tie, the vote of the chairman is decisive.

Board of Directors

IX. The Board of Directors consists of the president, the three vice-presidents and five members, who are appointed by the Federal Ministry for Trade, Industry and Building from the Kuratorium on its nomination. Apart from the vice-presidents one member of the Board of Directors must in each case be appointed from the number of those Kurators who have been nominated by the municipality of Vienna and by the Society for the Furtherance of the Technical Museum.

X. The term of office of the members of the Board of Directors is three years.

If one of the members of the Board of Directors appointed by the Federal Ministry for Trade, Industry and Building drops out during his term of office, the Federal Ministry for Trade, Industry and Building appoints another Kurator as a member of the Board of Directors, on the nomination of the Kuratorium, for the remainder of the term of office. If the member that drops out was nominated by the municipality of Vienna, or by the Society for the Furtherance of the Technical Museum for Industry in Vienna, the new member of the Board of Directors must also be appointed from the number of those Kurators that have been nominated by municipality of Vienna or by the Society.

XI. The president of the Kuratorium presides over the Board of Directors.

The Board of Directors elects one of the vice-presidents by absolute plurality as permanent substitute for the president, to take his place in case he is disqualified.

XII. The sphere of operation of the Board of Directors comprises:

1. The making of proposals to the Kuratorium regarding the operation of the Technical Museum and regarding its arrangement.
2. The making of other proposals and expressions of opinion to the Kuratorium in matters which fall within the sphere

Technical Museum, Vienna. Development of lighting apparatus.

of activity of the Kuratorium, particularly the proposals to the Kuratorium regarding the annual financial estimate of the Technical Museum.

3. The confirmation of the technical advisors of the Technical Museum in Vienna designated by the Society for the Furtherance of the Technical Museum.
4. The making of reports and proposals to the Federal Ministry for Trade, Industry and Building in regard to museum matters in so far as they are not reserved to the Kuratorium, especially the making of proposals in matters of the staff of the museum.
5. The conduct of the business of the museum in respect to administration and finance under the supervision of the Federal Ministry for Trade, Industry and Building.
6. Supervision of the business administration of the director.
7. The representation of the museum to the outside world.

XIII. The Board of Directors is summoned by the president or his permanent substitute according to requirements. It has a quorum if at least five members are present inclusive of the president. In case of a tie, the vote of the chairman is decisive.

XIV. The office of Kurator and of the members of the Board of Directors is honorary.

Director

XV. The Federal Ministry for Trade, Industry and Building appoints an expert of technical interests as director of the museum on the nomination of the Kuratorium.

The director is given by the Federal Ministry for Trade, Industry and Building on nomination of the Board of Directors the suitably qualified staff required for the museum service, which staff is under his direction.

In case of disqualification the director is represented by a technically suitable official of the museum who is appointed by the Board of Directors.

XVI. The director has charge of the immediate management of the museum. He attends to the current tasks of administration and directs the entire operation of the museum under the supervision of the Board of Directors.

The director takes part in the sessions of the Kuratorium and of the Board of Directors in a supervisory capacity.